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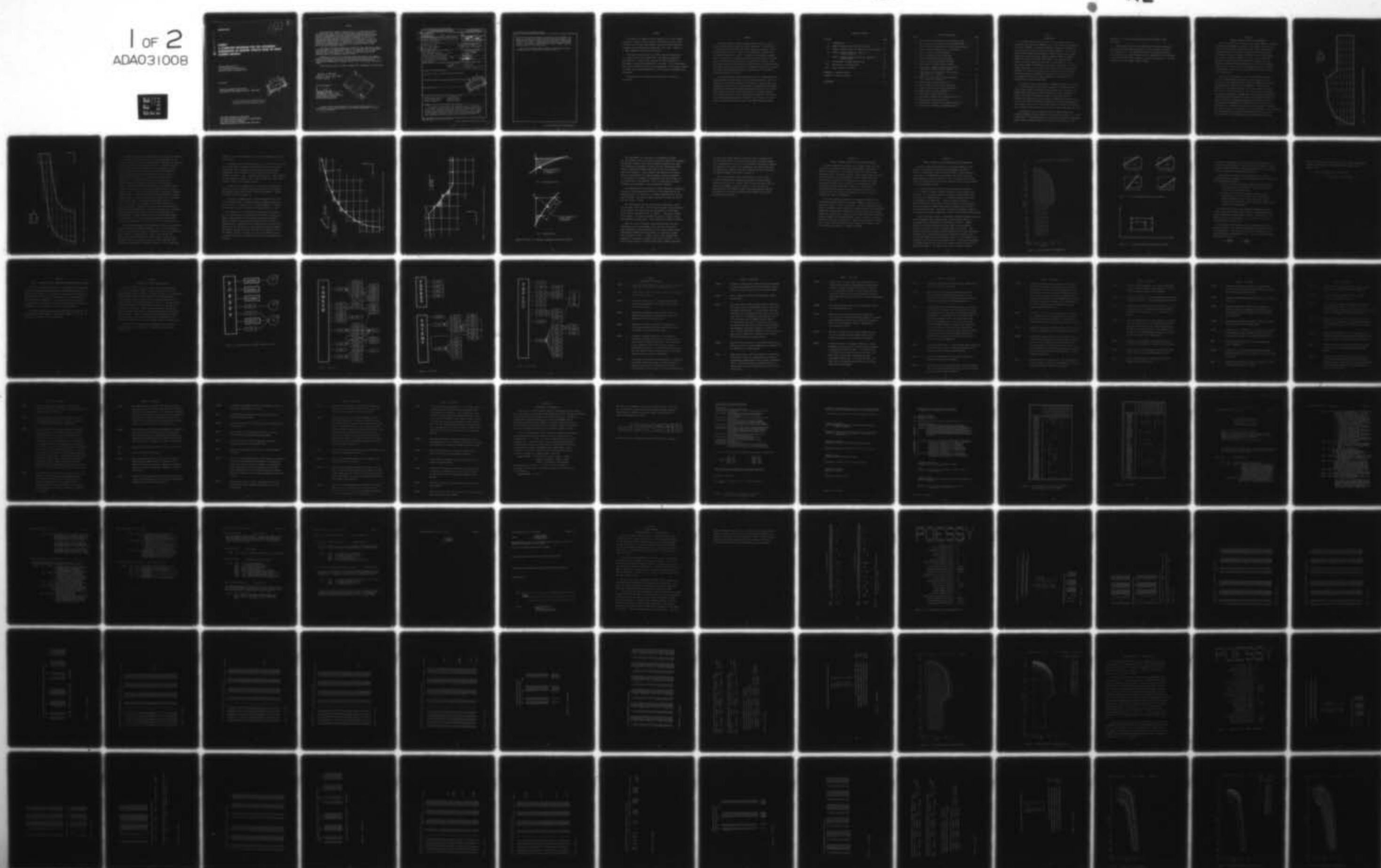

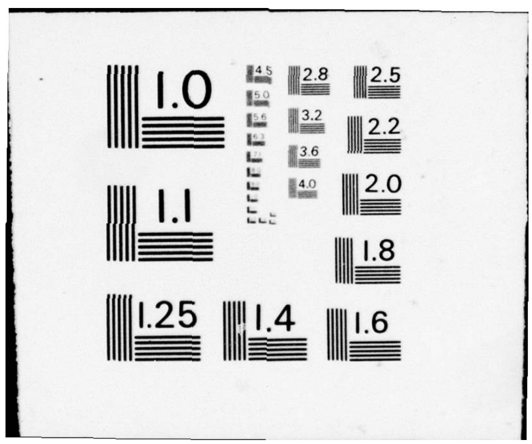
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POESSY
A COMPUTER PROGRAM FOR THE AUTOMATIC GENERATION OF REENTRY VEHICLE NOSE TIP FINITE ELEMENT MODELS

WEILER RESEARCH INC.
2672 BAYSHORE FRONTAGE ROAD
MOUNTAIN VIEW, CALIFORNIA 94043

JUNE 1976

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FINAL REPORT FOR PERIOD JUNE 1974 - APRIL 1976

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This technical report has been reviewed and is approved for publication.

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The theoretical background of the automatic nose tip finite element model generator, POESSY, is described. The POESSY computer program consists of four basic subprograms which perform different distinct steps in the automatic generation and translation of nose tip models. They are PGMESH which automatically generates the structural finite element mesh, PGPRES which translates the surface pressures and temperatures, PGTEMP which

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translates the indepth 2-dimensional temperature field and PGPLOT which plots the resultant finite element mesh and temperature contours. The POESSY code is designed to accept the output data from a thermochemical ablation, shape change, in-depth temperature response computer code and prepare it for input to a thermostructural analysis computer code with a minimum amount of effort by the user.

The use of the POESSY computer program is demonstrated by sample problems solved for a typical plug and shell nose tip.

PREFACE

This report was prepared by Weiler Research, Inc., 2672 Bayshore Frontage Rd., Mountain View, California 94043 under Contract F33615-C-74-0193, Project 627A, Task 627A0013, with the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433. Captain C. L. Budde (AFML/MXS) was the project monitor.

This report was written by F. C. Weiler, PhD, Weiler Research, Inc., between June 1974 and April 1976. The computer program was developed by F. C. Weiler, PhD, under WRI In House Research and Development funding between August 1971 to present. The work performed under Contract F33615-C-74-0193 covers preparation of the computer program for public release and documentation of the theoretical development and programming.

The manuscript of this report was released by the author in April 1976.

SUMMARY

The POESSY computer program was developed to help fill a gap in existing reentry vehicle nose tip analysis capability. Programs exist to analyze the ablating shape and indepth temperature response, such as PAGAN (Reference 4) and to analyze the thermostructural response such as DOASIS (References 1, 2, and 3). However, no preprocessor programs exist to automatically translate the output from a program such as PAGAN into an appropriate form for input to a program such as DOASIS. This translation task is not trivial since different forms of problem definition are used in these two analysis tools. Consequently, POESSY was developed to perform this translation process automatically, with a minimum of required user input information.

The POESSY computer program consists of four basic subprograms which perform different distinct steps in the translation process. They are PGMESH which automatically generates the structural finite element mesh, PGPRES which translates the surface pressure and temperature information, PGTEMP which translates the indepth temperature distribution and PGPLOT which plots the resultant finite element mesh and isotherm contours. This report describes the theory behind these subprograms, the form and type of input data necessary to run POESSY (User's Manual) and several sample problems illustrating the use of the POESSY computer program.

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SECTION I

INTRODUCTION

The POESSY computer program consists of four subprograms which perform the mesh generation (PGMESH), the surface pressure and temperature translation (PGPRES), the indepth temperature translation (PGTEMP) and the plotting of the mesh and isotherm contours (PGPLOT). All of these programs except PGMESH were developed by simply modifying the existing DOASIS pre- and post-processor computer programs PRSINT (for PGPRES), TEMINT (for PGTEMP) and CONTUR (for PGPLOT). The complete DOASIS family of computer programs is described in References 1, 2, and 3, with PRSINT, TEMINT and CONTUR being described in Reference 2. Since the POESSY subprograms are so closely tied to these pre- and post-processor programs, the reader should consult these references for relevant and additional theory and programming techniques, since this report uses the information contained in these references to help describe the theory behind the POESSY subprograms.

The automatic nose tip mesh generator PGMESH is described in Section II. It was developed for the specific purpose of generating nose tip finite element meshes and therefore uses techniques not contained in the DOASIS general purpose mesh generator MESHGN described in Reference 2. However, the overall philosophy of using an associated indical I-J grid with the coordinate R-Z grid is used in PGMESH and therefore Sections 1 and 2 of Reference 2 should be consulted for a better understanding of this concept. Section II of this report basically describes the technique used to automatically generate the mesh from the given PAGAN code input data.

The automatic nose tip pressure translator PGPRES, temperature translator PGTEMP and plotter PGPLOT are described in Sections III, IV, and V respectively. These subprograms are direct modifications of the programs PRSINT, TEMINT and CONTUR described in Reference 2, respectively, and

therefore will referenced directly when describing PGPRES, PGTEMP and PGPLOT.

A complete description of the POESSY computer program is presented in Section VI, followed by a description on how to modify the program size in Section VII. The POESSY User's Manual is presented in Section VIII followed by two sample problems given in (Appendix A) which illustrate the use of the POESSY code. Appendix B contains a description of plotting software used by the POESSY computer program.

SECTION II

PGMESH AUTOMATIC NOSE TIP MESH GENERATOR

The set of subroutines contained in the segment PGMESH are designed to automatically generate a structural finite element mesh when given only the outside boundary contour of the solid body. This outside boundary definition is all that is needed, provided some criterion is choosen as to how to subdivide the interior into finite elements. The criterion choosen for POESSY is to use a "regular rectangular pattern" of finite elements, with transition elements, that is, arbitrary triangles and quadrilaterals, existing along the boundary contour. This concept of a regular rectangular pattern of elements is graphically illustrated for a plug and shell nose tip in Figures 1 and 2 respectively.

When viewing these figures, one will notice that the origin of the rectangular pattern is chosen to coincide with the axis of revolution of the nose tip for the radial (R) coordinate and with the backside surface for the axial (Z) coordinate. The main reason basically for this choice of pattern and origin is that for receding nose tips the outside front surface is the only surface which changes as recession takes place. Consequently, the location of elements when referenced from the backside will remain fixed provided the size and shape of the basic rectangular element remains fixed for meshes of the nose tip at different points in time except for elements on the surface which are effected by the recession of the surface. Therefore, one can trace the history of loading at a particular point, since for almost all of the elements the element encompassing that point will be the same element for the different meshes for different points in time.

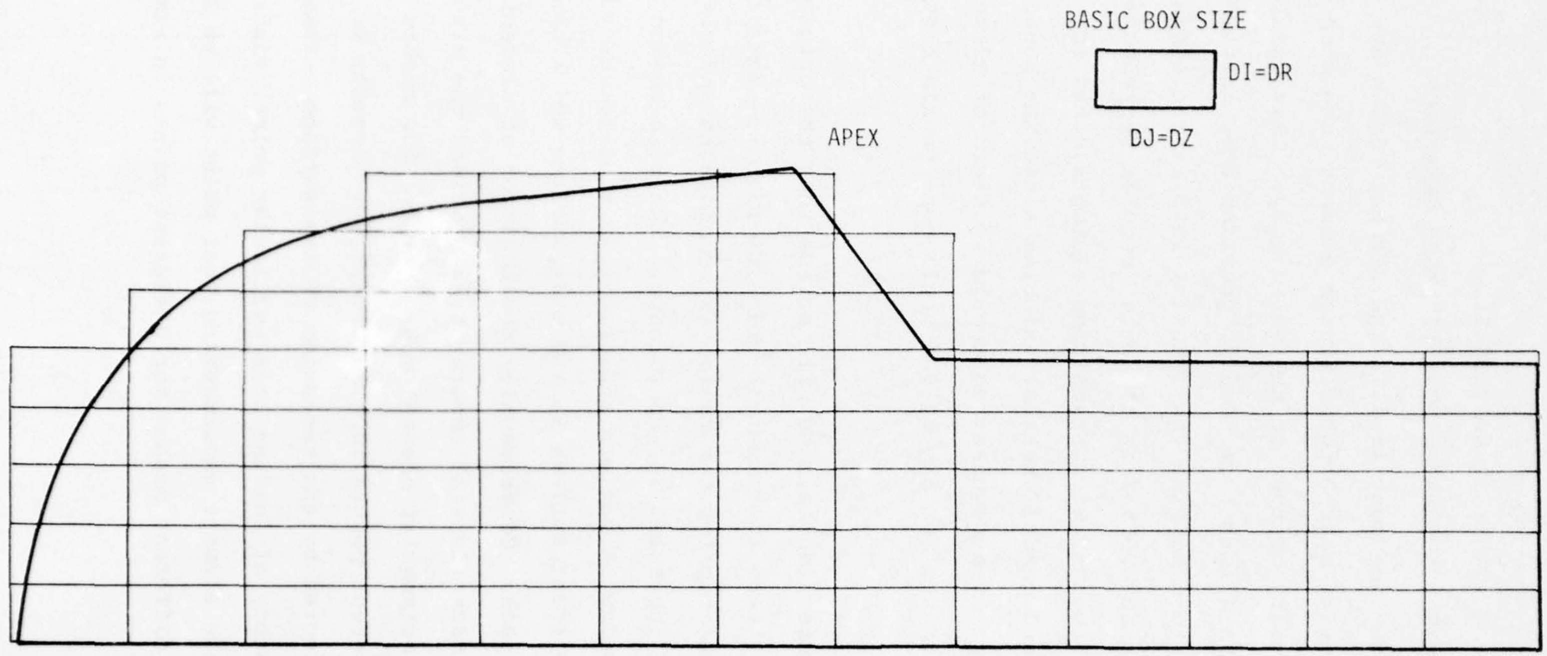


Figure 1. Typical Plug Nose Tip Blocked Into Rectangular Mesh.

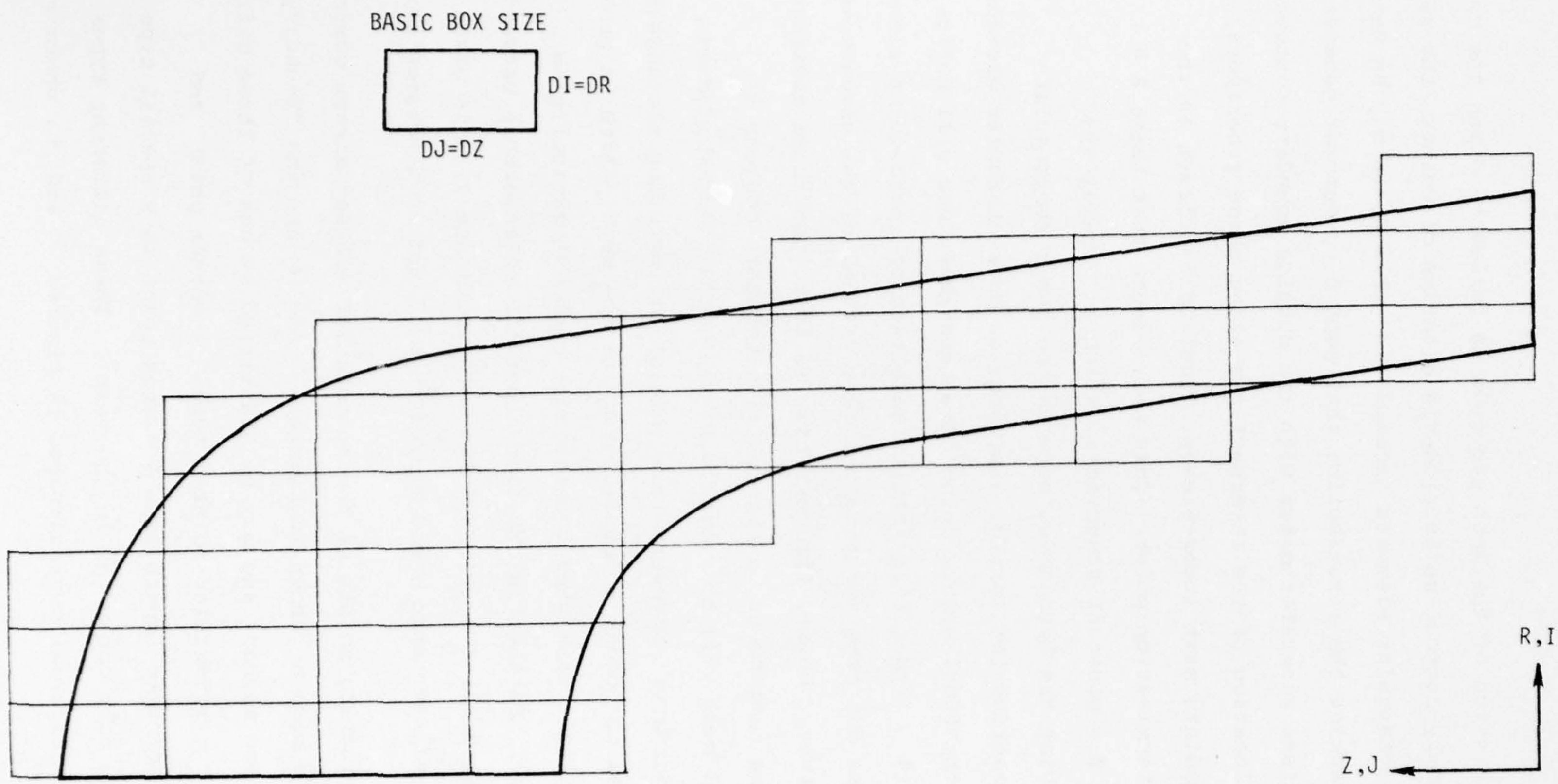


Figure 2. Typical Shell Nose Tip Blocked Into Rectangular Mesh.

The generation of the mesh proceeds as follows: Given the complete outside boundary contour definition via a series of points, the set of regular rectangular elements encompassing this shape may be determined by simply checking the intersection that each R = constant generator and Z = constant generator makes with the outside boundary contour. Knowing the location of the intersections along these generators, then the immediate next inter-element location is chosen as the generator's termination point. This will ensure that these R = constant and Z = constant generators, which are simply the lines describing the boundaries between the basic rectangular elements, describe the correct distribution of rectangular elements to comprise the final mesh. Using this technique, one will notice in Figures 1 and 2 that this initial selection of rectangular elements both protrudes out from and into the area defined by the given outside boundary contour. Hence, the next task is to adjust those rectangular elements lying next to or on this outside boundary contour so that the final mesh will be composed of reasonably shaped elements along this boundary. However, this initial sizing using rectangular elements fixes the nodal point I-J grid for the mesh, which is probably the most difficult task when generating a mesh automatically as described here. Further information about the relationship between the mesh nodal point I-J grid and its R-Z coordinate grid is given in Section 1 of Reference 2 and therefore will not be discussed here.

The terminating points of the rectangular element arrays comprising the nose tip's mesh as shown in Figures 1 and 2 are the "boundary points" of these meshes, and may be classified as one of three different types: type T = triangular point type C = corner point and type E = end point (a fourth type A = apex point is a special type and applies to only one point in the mesh). These different types of points are graphically illustrated in Figures 3 and 4, where the

symbols T, C and E are shown next to the type of boundary point which they describe.

A triangular (type T) boundary point is one in which both of the two sides of the basic rectangular element connecting to it, intersect the boundary contour, somewhere along these two connecting sides. Consequently, this triangular point and these two intersections comprise a triangle; hence, the name triangular point. These triangles are shown shaded in Figures 3 and 4 , and as shown, can exist either outside or inside of the boundary contour.

A corner (type C) boundary point is one in which one of the two sides of the basic rectangular element connecting to it intersects the boundary contour, and the other connecting side doesn't. Typical (C) points are shown in Figure 3 .

An end (type E) boundary point is one which does not fall into the two previous types of classifications, but simply represents the "end" of either a R = constant or Z = constant generator. Hence the name end point. Typical (E) points are shown in Figures 3 and 4 .

The readjustment of triangle points is performed as follows: The two intersections of the connecting sides define a straight line segment comprising part of the structural mesh outside boundary, shown by a dashed line for a typical triangular point in Figure 5a. A perpendicular is formed from the triangular point (T) to this line segment, and the intersection of this perpendicular and the (dashed) line segment comprises the final location of the triangular point on the boundary, as shown in Figure 5a. Hence, the triangular point is simply translated to the boundary contour via this "perpendicular" technique.

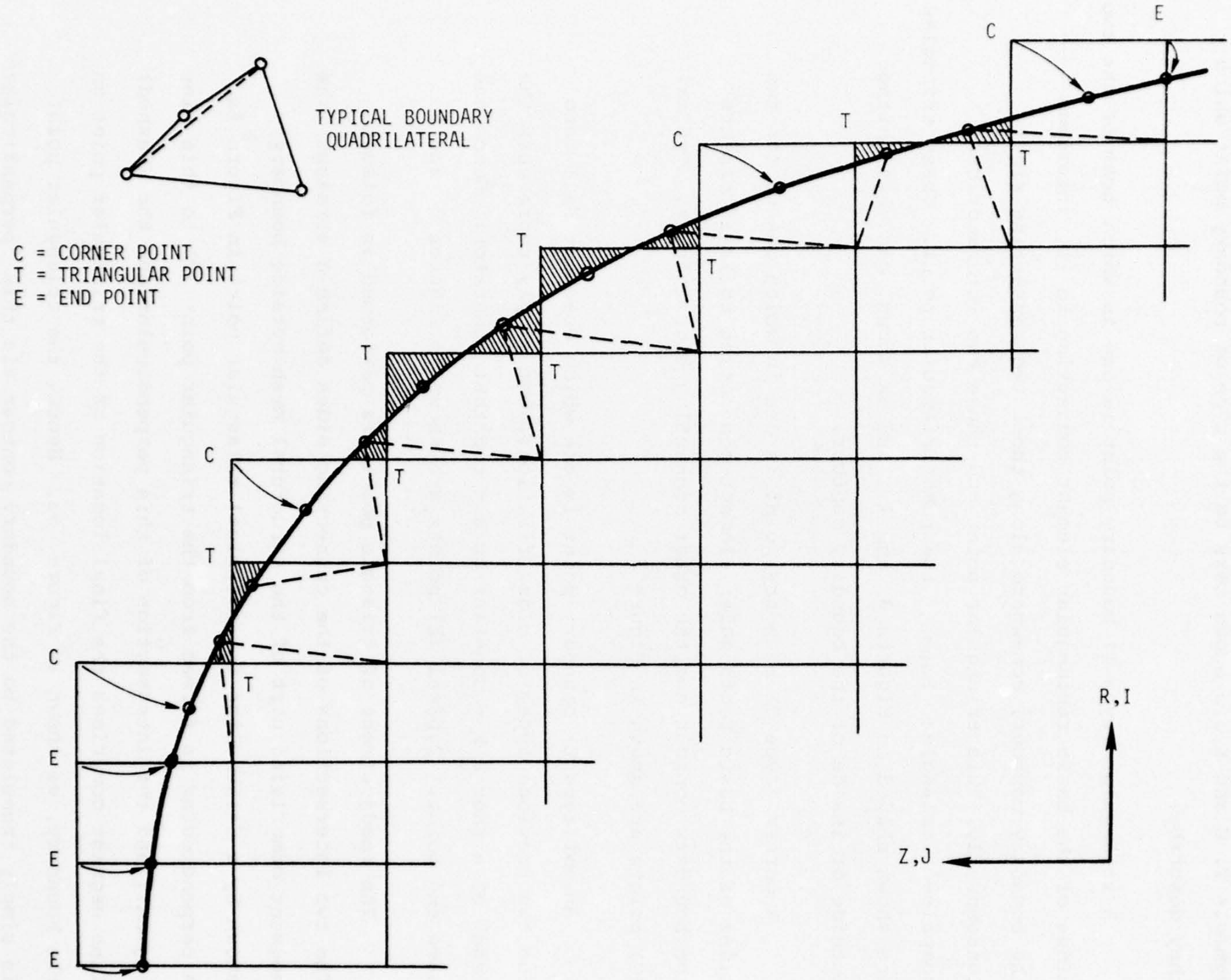


Figure 3. Initial Sizing of Nose Section of Plug or Shell Nose Tip.

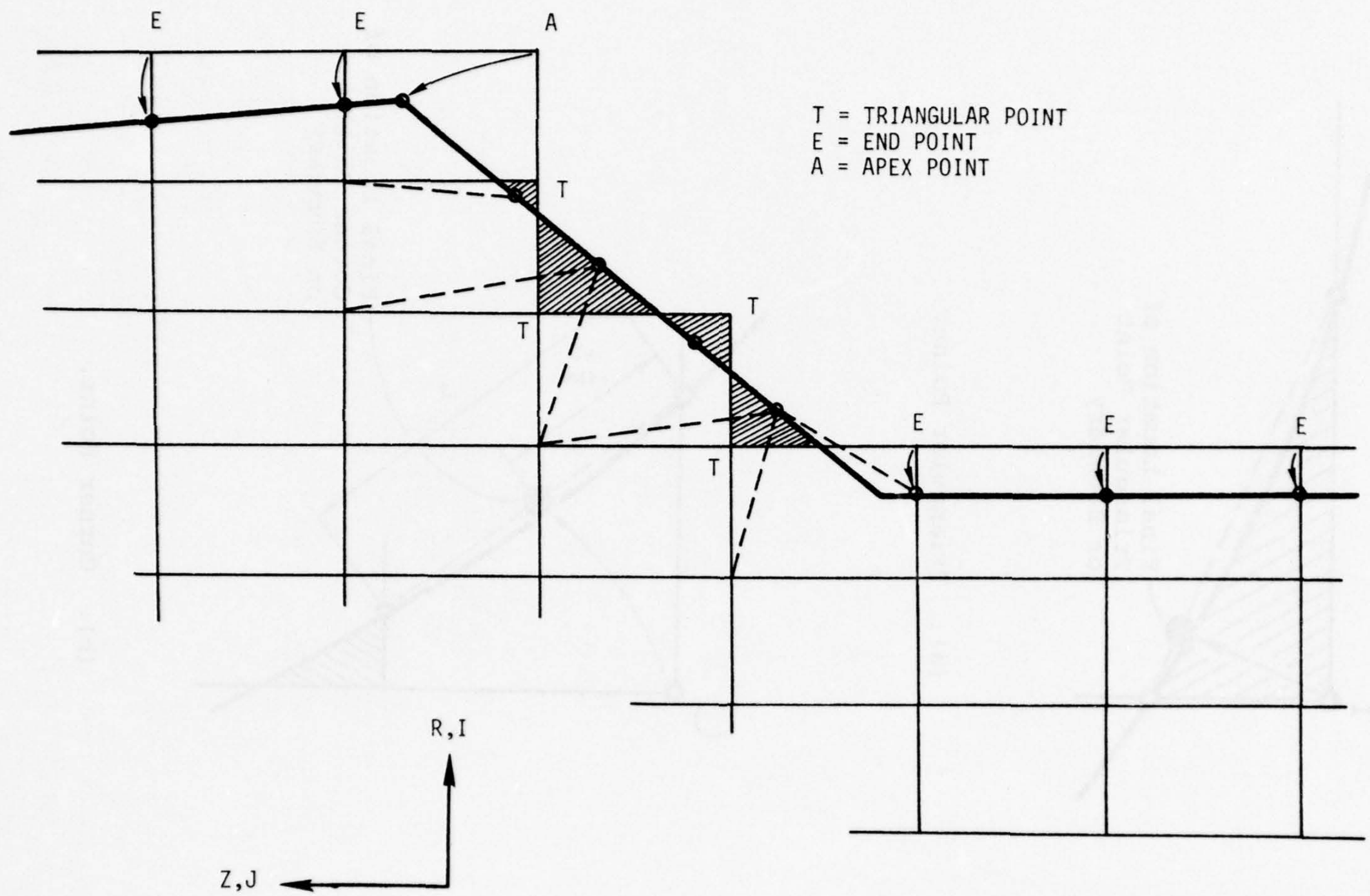
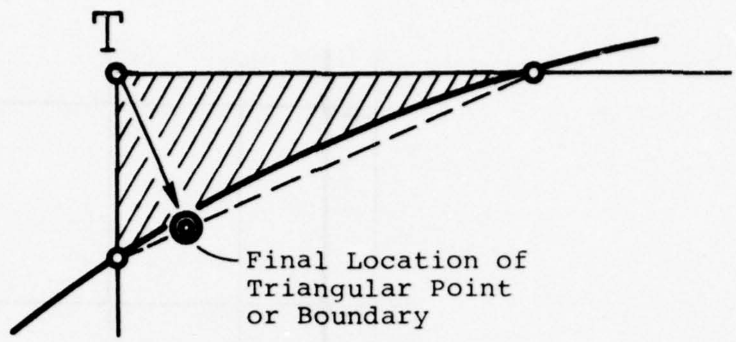
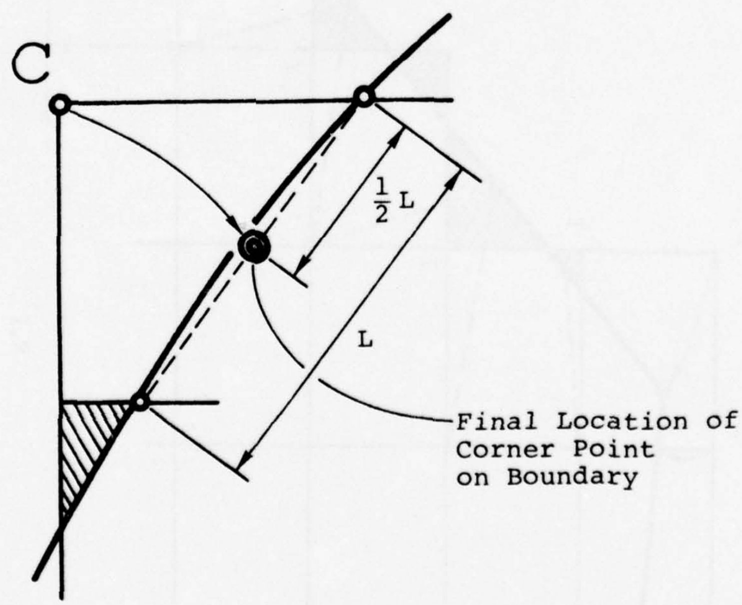


Figure 4. Initial Sizing of Midsection of a Plug Nose Tip.



(a). Triangular Point.



(b). Corner Point.

Figure 5(a) and (b). Typical Triangular and Corner Points.

The readjustment of corner points is performed as follows: The one connecting side of the basic rectangular element which intersects the boundary is taken, along with the element's parallel side (which also intersects the boundary), to again yield two intersections which define a straight line segment comprising part of the structural mesh outside boundary. This is shown by the dashed line in Figure 5. These two intersections are simply averaged, yielding the midpoint of this boundary line segment, thus comprising the final location of the corner point on the boundary. Hence, a corner point is simply translated to the boundary via this "averaging" technique.

The readjustment of an end point is simply performed by translating the point to the boundary location which is the intersection of the boundary and the R = constant or Z = constant generator which the end point describes. This type of simple translation is shown for end (E) points in Figures 3 and 4 .

The fourth special type of point, called an apex point, exists for plug type of nose tips. This is the point which is the intersection of the outside front surface and the ramp portion of the backside surface, and is indicated as such in Figure 1. This point, labeled (A) in Figure 4 is simply translated to the actual location of the apex defined by the input data. This translation is shown in Figure 4

After all of the triangular, corner and end points have been readjusted to lie on the boundary of the nose tip, the original basic rectangular elements connecting to these points become general quadrilateral elements along the boundary, as indicated by dashed lines in Figures 3 and 4 . However, some of these quadrilateral elements are ill-shaped, as shown by the insert in Figure 3 , i.e., two of the four sides of a general quadrilateral element almost form

a straight line (shown dashed in the insert figure) indicating that this particular element is better represented by a triangular element than a quadrilateral. Hence, all of the boundary quadrilateral elements are checked for this type of ill-conditioning, and if bad enough they are changed into compatible triangular elements by simply eliminating the boundary midpoint (see insert in Figure 3).

Thus, the structural finite element mesh of a plug or shell nose tip is automatically generated from knowing only the boundary contour of the nose tip. A typical mesh of a plug and shell nose tip, generated by PGMESH, is shown in Figures 13 and 15 respectively, where the small "box" symbols plotted along the boundaries represent the original set of points received from the PAGAN code input data, defining these boundaries.

SECTION III

PGPRES AUTOMATIC NOSE TIP PRESSURE FORCE TRANSLATOR

The set of subroutines contained in the segment PGPRES are almost identical to the DOASIS preprocessor program PRSINT, described in Section 4 of Reference 2. The boundary contour for both the input PAGAN mesh and the generated structural finite element mesh are already known and reside in core when PGPRES is called, and therefore need not be input as described in the description of PRSINT. The actual translation technique used in PGPRES is the "normalized arc length translation" technique described in Section 4.3 of Reference 2. The backside reacting surface is described exactly the same way as in PRSINT, where the variable ISHPLG defines the type of reacting surface (see Figure 20, Reference 2).

Since the technique and theory are completely described for the preprocessor program PRSINT and, therefore, PGPRES, in Section 4 of Reference 2, they will not be covered here. The only difference between PRSINT and PGPRES is that in addition to translating the surface pressures, PGPRES also simultaneously translates the surface temperatures, thereby eliminating a duplication in coding of the surface temperature translation normally included in the segment PGTEMP. Since the surface translation technique is the same for pressures in PRSINT and temperatures in TEMINT, both of these surface translations were incorporated in PGPRES instead of including them seperately in PGPRES and PGTEMP.

SECTION IV

PGTEMP AUTOMATIC NOSE TIP TEMPERATURE FIELD TRANSLATOR

The set of subroutines contained in the segment PGTEMP are very similar to the DOASIS pre-processor program TEMINT, described in Section 3 of Reference 2, with one major difference. That difference is locating in the PAGAN mesh the "element" that contains the point whose temperature is being translated. Again, no need exists to input either the PAGAN mesh or the structural mesh since they are both resident in core when PGTEMP is called.

The input PAGAN mesh contains basically two types of elements: (1) a rectangular element, basically contained in the interior of the mesh, and (2) a rectangular element in which one or more corners are cut off by the boundary contour, i.e., transition elements lying along the boundary of the PAGAN mesh. To help illustrate this point, a typical PAGAN plug nose tip mesh is shown in Figure 6. One can observe that the rectangular elements lying along the boundary have from one to three corners missing. This point is further illustrated in Figure 7, which shows a rectangular element that has one, two, and three corners missing.

When two and three corners of a boundary rectangular element are missing, this rectangular element simply becomes a general quadrilateral or a triangular element respectively, as indicated in Figure 7. However, when only one corner is missing, then the shape of the rectangular element is a quintic, that is, a polygon having five vertices. Interpolation within such a polygon could be performed via a Schwarz-Christoffel technique, but it proves easier to simply subdivide the quintic into a triangle and quadrilateral as indicated in Figure 7. This subdivision is performed in only two of the five possible ways. In both ways the boundary line segment comprises one side of the triangle as shown by the top two diagrams in Figure 7. The aspect ratio of the triangle is checked

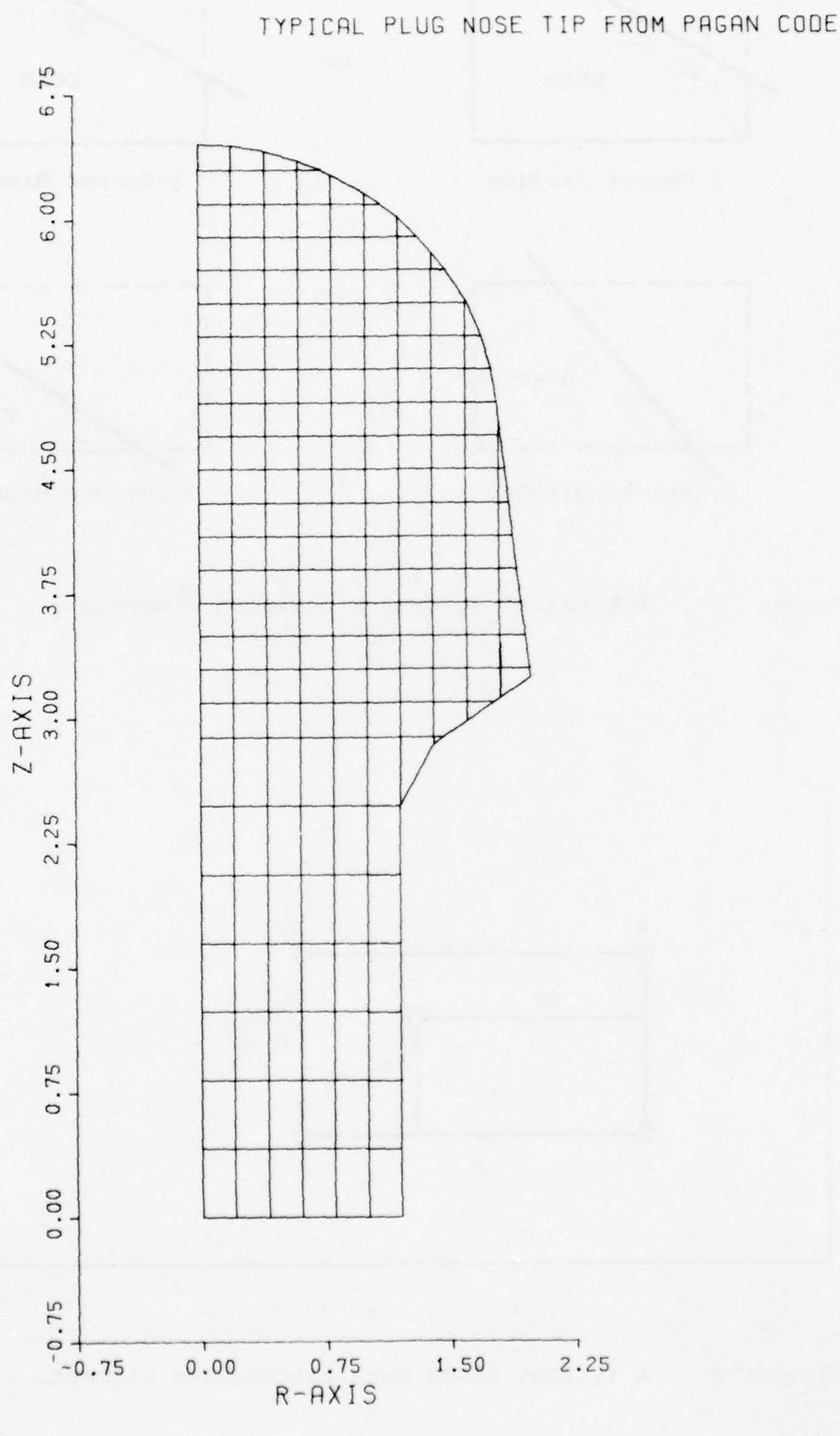


Figure 6. Typical Plug Nose Tip From PAGAN Code.

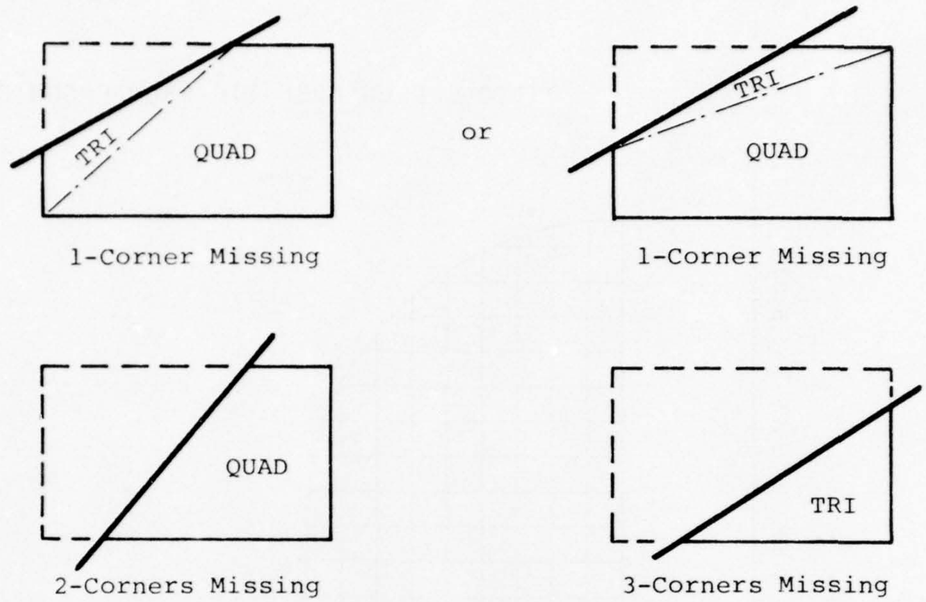


Figure 7. Typical PAGAN Mesh Transition Elements

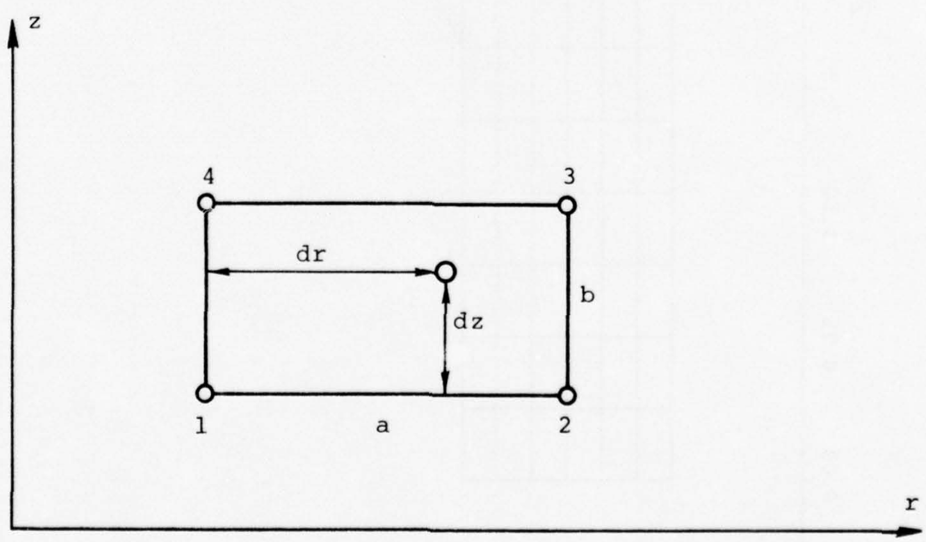


Figure 8. A Typical PAGAN Mesh Rectangular Element.

for these two possibilities, and the one with the best conditioning is chosen as the subdivision to use for interpolation purposes. Hence, all of the PAGAN mesh boundary "transition" elements may be represented by general triangular and quadrilateral elements.

The temperature translation for the interior nodal points is performed as follows (remember that the boundary nodal point temperatures were interpolated by PGPRES):

1. All of the interior rectangular elements are checked to see if the nodal point lies within them, and if one is found, it is used for the interpolation.
2. If none of the interior rectangular elements contains the nodal point, it must lie within one of the boundary transition elements. They are all checked and the one containing the nodal point (either triangular or quadrilateral) is used for the interpolation.

The technique and theory for translating temperatures within a general triangular and quadrilateral element is completely described for the preprocessor program TEMINT in Section 3 of Reference 2, and therefore will not be reiterated here. This applies to all of the transition element interpolations.

The technique for translating within a rectangular element is exactly the same as for a general quadrilateral, described in Section 3.3 of Reference 2. The only difference being the determination of the non-dimensional coordinates ξ^* and η^*. They are simply calculated as follows (see Figure 8).

$$\xi^* = 2\left(\frac{dr}{a}\right) - 1 \qquad \eta^* = 2\left(\frac{dz}{b}\right) - 1$$

Knowing the location of the nodal point (ξ^*,η^*) within the rectangular element, the temperature is interpolated using Equation (24) of Reference 2 via

$$T(r,z) = \frac{1}{4}\Big[(1-\xi)(1-\eta)T_1 + (1+\xi)(1-\eta)T_2 + (1+\xi)(1+\eta)T_3 + (1-\xi)(1+\eta)T_4\Big]$$

SECTION V

PGPLOT AUTOMATIC NOSE TIP MESH AND TEMPERATURE CONTOUR PLOTTER

The set of subroutines contained in the segment PGPLOT are almost identical to the DOASIS post processor program CONTUR, described in Section 6 of Reference 2. The plotting software used is identical to that described in Section 1.1 of Reference 2, and is reproduced for convenience here in Appendix B. The mesh plotter and temperature contour plotter are the same as that contained in CONTUR, with minor differences in connection with the title actually plotted.

Since the technique and theory are completely described for the post processor program CONTUR, and therefore PGPLOT, in Section 6 of Reference 2, they will not be covered here.

SECTION VI

DESCRIPTION OF POESSY COMPUTER CODE

A complete listing of the source card images is not presented here due to its extensive length. Instead, a block outline of the different subroutines and functions is shown in Figure 9. The subroutines PGMESH, PGPRES, PGTEMP and PGPLOT shown in "dark" outlined boxes, call other subroutines to perform their functions and therefore are shown by separate block outline diagrams in Figure 9. The Plot Software for PGPLOT is shown in a "dashed" outlined box, and is explained in Appendix B of this report. There are three tape units (which may be tapes, disc files, drum files, or any other peripheral units available) shown in Figure 9. TAPE 2 is the PAGAN code data input tape. TAPE 3 is the save tape, used to store (in binary) the resultant nose tip finite element meshes for later use by DOASIS. TAPE 9 is the plot tape.

Table 1 is a brief summary of each subroutine and the function that it performs. This will be done in alphabetical order or the subroutine name.

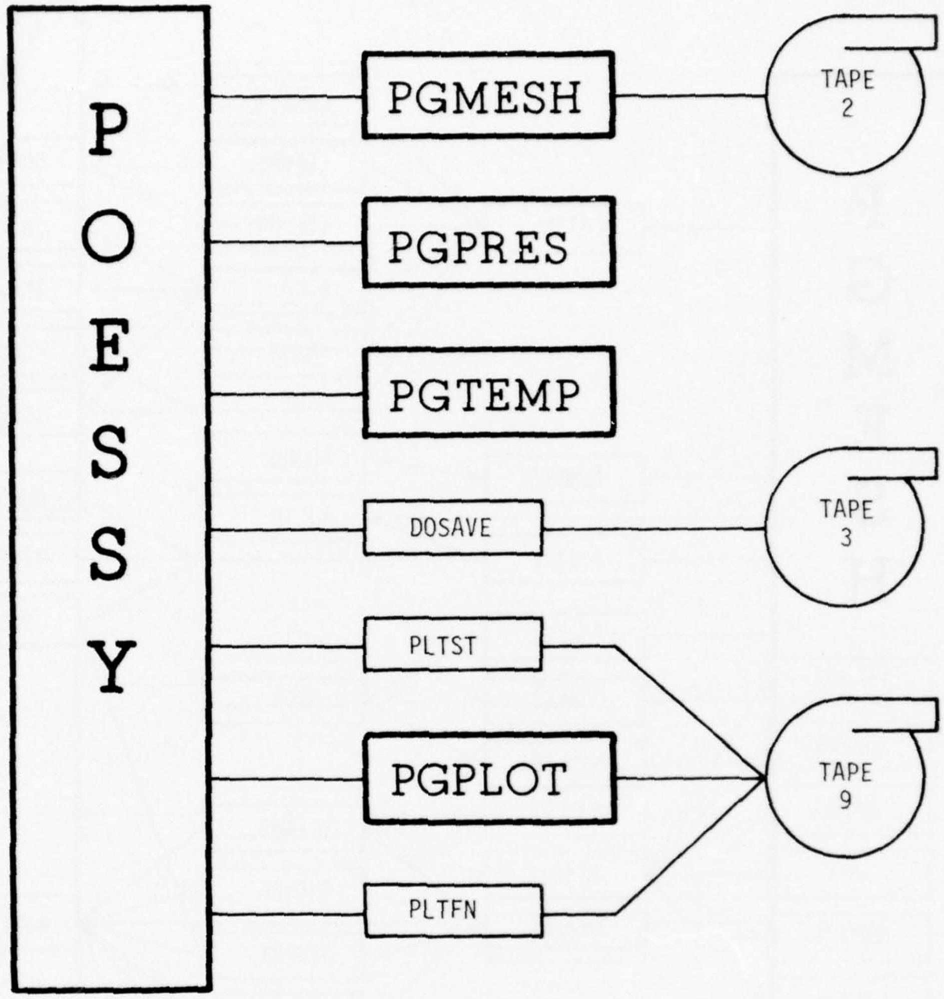


Figure 9. Block Outline of POESSY Computer Program.

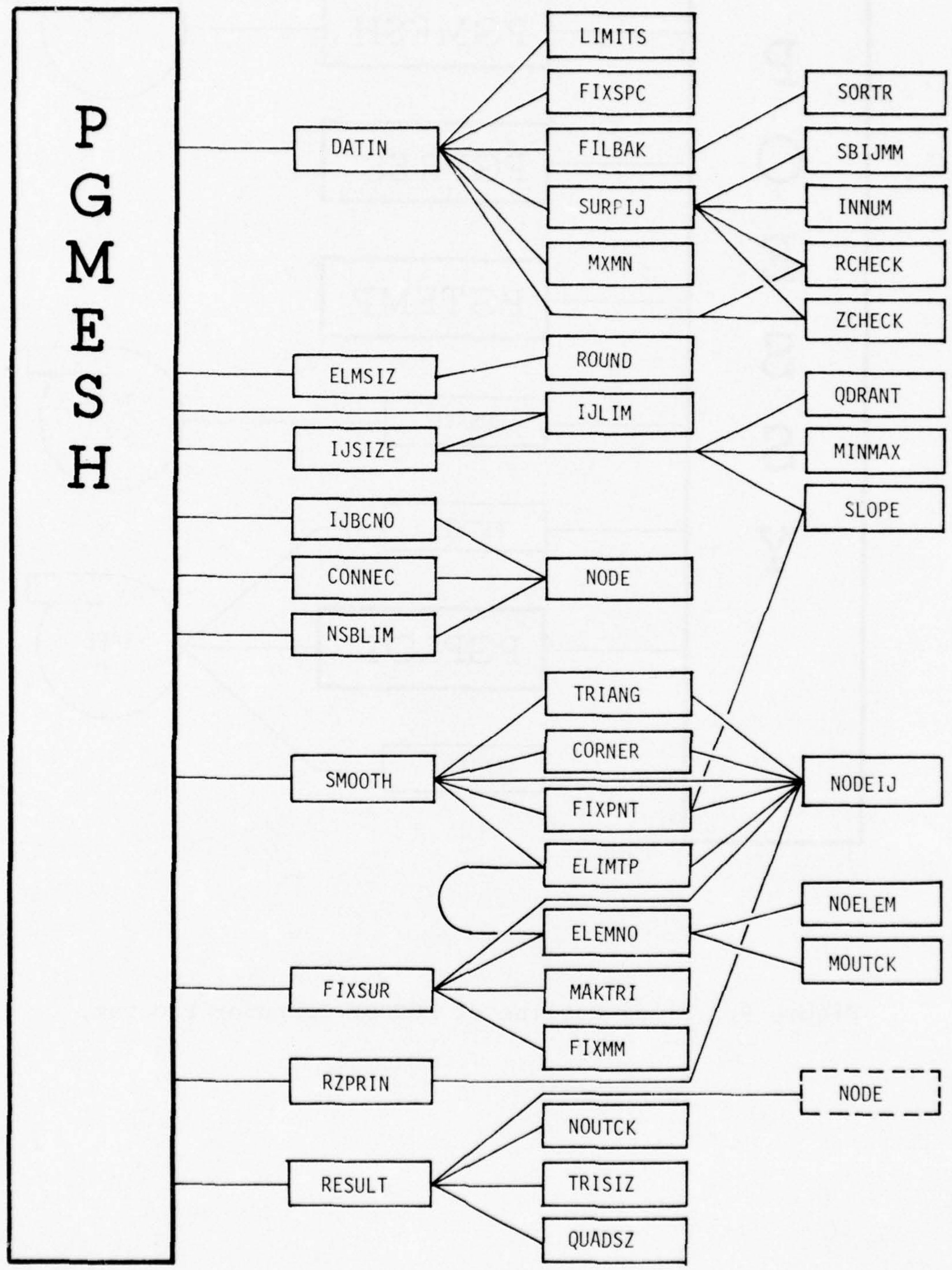


Figure 9. Continued.

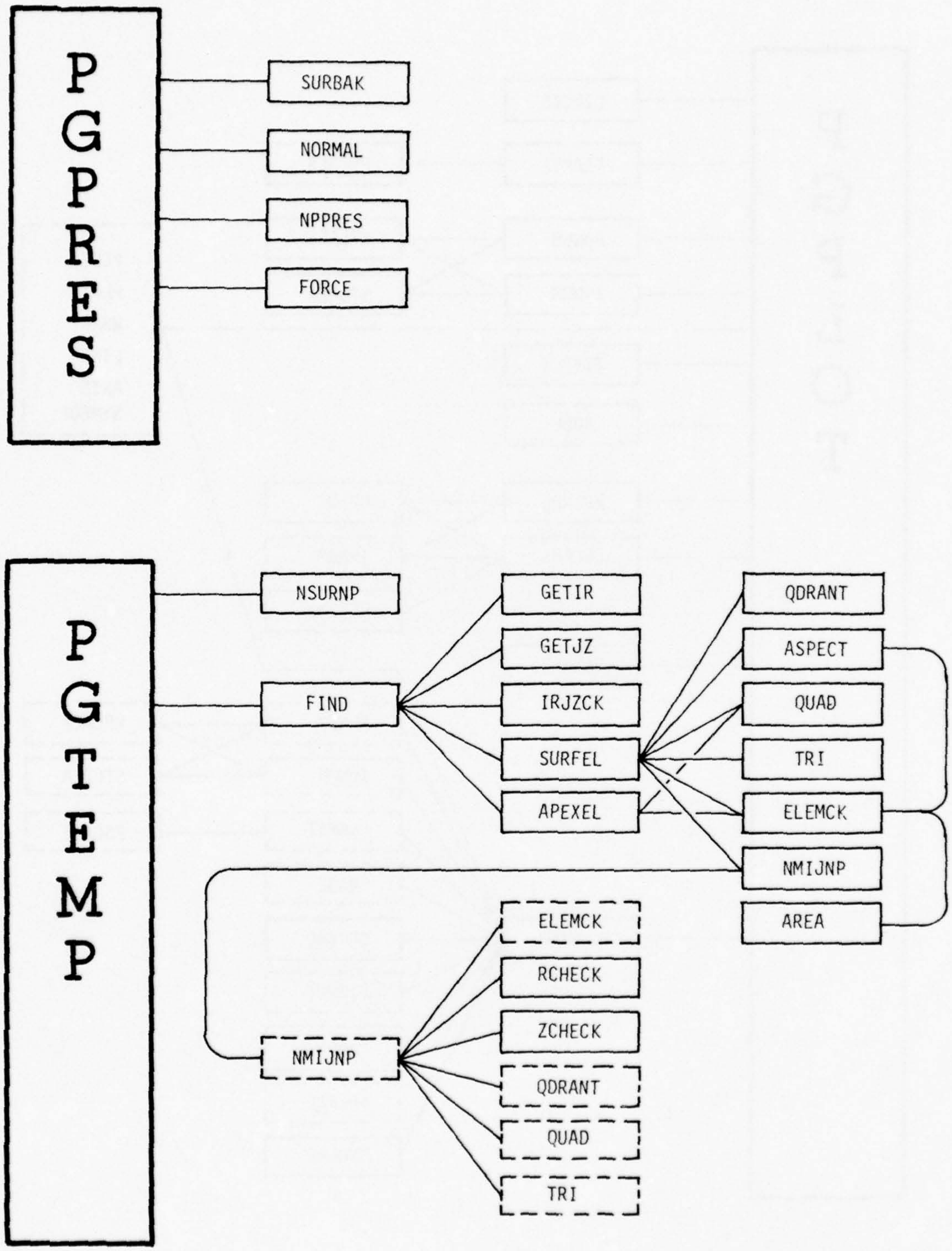


Figure 9. Continued.

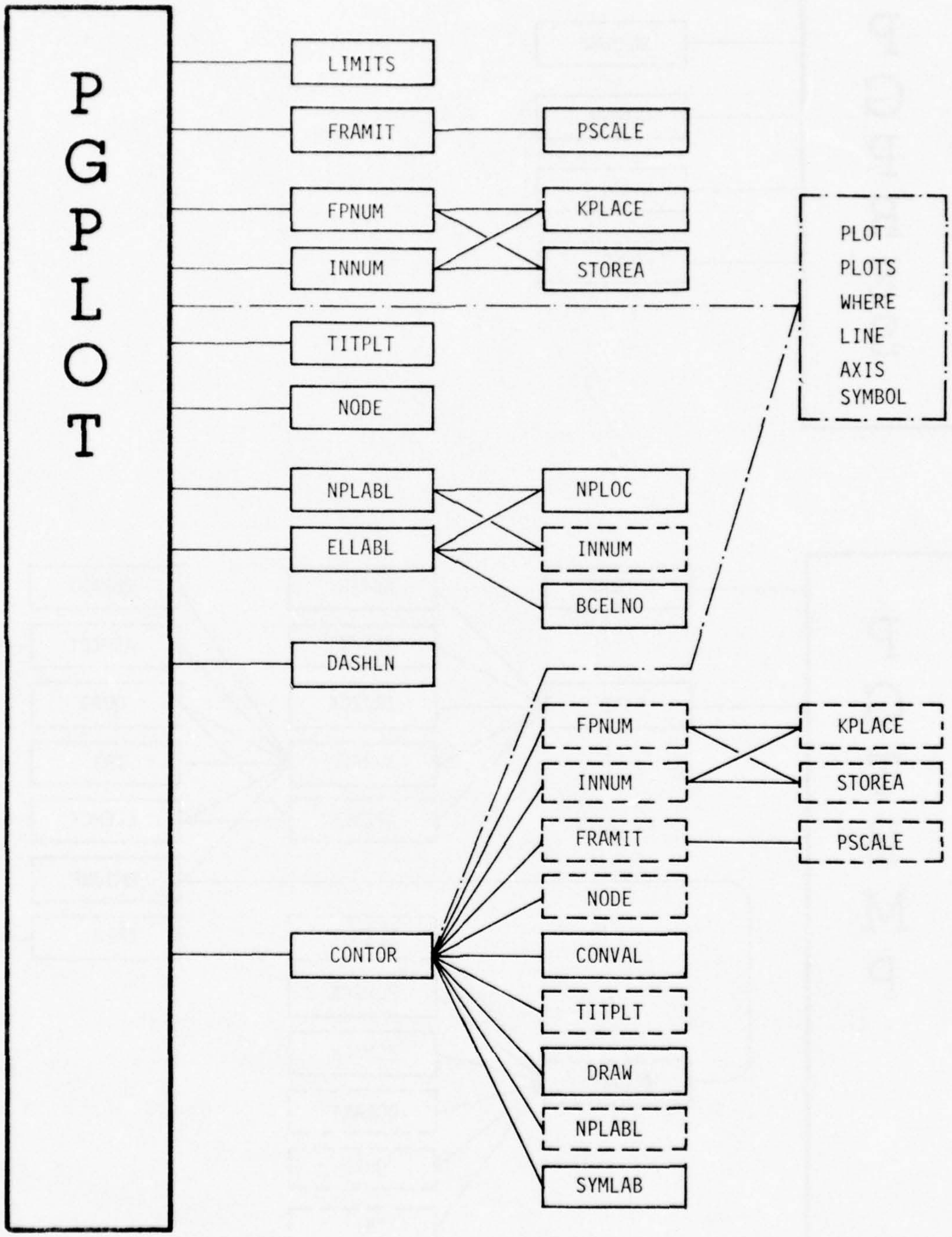


Figure 9. Concluded.

TABLE 1

SUBROUTINES AND FUNCTIONS

APEXEL	--	Checks the "apex" element of either a shell or plug nose tip to see if a given point (P,Q) lies within it.
AREA	--	Calculates the area of a traiagle given the coordinates of it's three vertices.
ASPECT	--	Checks the aspect ratio of a triangle and determines the ratio of the height to the length of the longest side of the triangle.
BCELNO	--	Determines the boundary contour element number (M), given two of the element's nodal points lying on the boundary of the finite element mesh.
CONNEC	--	Generates the element conductivity information by establishing the four nodal point numbers which define the element in the finite element mesh.
CONTOR	--	Generates a isotherm contour plot on the resultant translated temperature field of a nose tip, that is, it draws lines of constant temperature: Either automatic or user supplied scaling may be used to make this temperature contour plot. It also annotates the contour plot with symbols along the boundary contour indicating different values of constant temperature.
CONVAL	--	Interrogates the temperatures being plotted, to determine the maximum and minimum values, and then automatically chooses plot values of the temperatures such that a minimum number of values exist in the final determination.

TABLE 1. Continued.

CORNER	--	Eliminates a "corner point" which exists on the boundary I-J grid to help smooth out the final boundary surface contour in a manner similar to the subroutine TRIANG.
DASHLN	--	Draws a dashed line similar to the plotting software routine LINE.
DATIN	--	Inputs the nose tip mesh information from a PAGAN code save tape, either via reading from cards or reading from the PAGAN code save tape. It redistributes this input information into a form which may be used by the POESSY code, that is, it redistributes the coordinate and I-J grid information into the POESSY internal format. It redistributes the interior coordinate points into 2-dimensional arrays which are used for mesh generation and temperature translation purposes. It checks the list of surface nodal point numbers to see if any surface nodal point is duplicated or belongs to the interior arrays, and eliminates any duplications.
DOSAVE	--	Writes the final structural finite element mesh onto the DOASIS save tape in a format compatible for inputting into the DOASIS finite element program.
DRAW	--	Draws contour plots, given the coordinate variables and the function variable in 2-dimensional arrays and the appropriate maximum/minimum limits of these 2-dimensional arrays. Additional features included the ability to exclude certain function variable values from the final contour plot.

TABLE 1. Continued.

ELEMCK	--	Checks to see if a given point (P,Q) lies within or on a quadrilateral element by subdividing the quadrilateral into four triangles, formed by the point (P,Q) and one of the quadrilateral's sides. It then checks to see if the area of these four triangles is positive, and if so, establishes that the point lies within the given quadrilateral element.
ELEMNO	--	Determines the element numbers of elements which connect to a given nodal point (N).
ELIMTP	--	Checks the degree of singularity which might exist at a corner of a surface quadrilateral element, and changes this quadrilateral element into a compatible triangular element if the singularity exceeds a predetermined (user supplied) criteria.
ELLABL	--	Annotates the boundary of the finite element mesh with the list of boundary contour element numbers, placed appropriately next to the elements on the boundary.
ELMSIZ	--	Determines the basic rectrangular element size (DI,DJ) based upon the total area of the nose tip being composed of approximately (NELEM) elements. If either or both of the basic spacing data DI and/or DJ is given, then these values are used when determining the basic rectrangular element size. If neither are given, then these values are choosen based upon the nose tip being composed of NELEM elements.

TABLE 1. Continued.

FETCHA	--	Extracts an alpha-numeric character from a computer word, given the position in the word.
FILBAK	--	Adds to the list of backside boundary surface nodal point numbers, those points that were given in the interior definition of the mesh and were not originally included in the complete backside boundary list.
FIND	--	Locates the point in the PAGAN mesh where a given nodal point from the structural finite element mesh lies, and then translates the temperature of this given structural nodal point. It first checks all of the basic PAGAN rectangular elements to see if the point lies within one of these elements and, if so, it uses this basic rectangular PAGAN element to translate the temperature. If the point does not lie within one of these basic rectangular elements, then all of the transition elements existing along the outside and backside surfaces are checked and the subroutines TRI or QUAD are called to translate the given temperature.
FIXMM	--	Adjusts the nodal point I-J grid maximum/minimum information to reflect the fact that a boundary contour nodal point has been eliminated from the mesh definition.
FIXPNT	--	Finds the intersection of two lines, each of which is defined by two nodal point numbers.
FIXSPC	--	Changes the units and reference datum of the basic spacing data received from the PAGAN save tape, that is, the basic spacing variables RSPACE and ZSPACE.

TABLE 1. Continued.

FIXSUR	--	Checks the surface nodal point number lists to see if any have been flagged for elimination and eliminates these points from the final surface nodal point list. It reorders this list of nodal point numbers to reflect the fact that certain points have been eliminated and updates the nodal point I-J grid maximum/minimum arrays to reflect that certain boundary contour nodal points have been eliminated from the resultant structural finite element mesh definition.
FORCE	--	Calculates the total axial and radial forces existing on a boundary surface line segment which is subjected to normal and tangential pressures. It assumes that these pressure forces are constant along this line segment.
FPNUM	--	Encodes a floating point number from internal format into equivalent alpha-numeric (F) format for plot annotation.
FRAMIT	--	Automatically determines all of the necessary sizing data to make the resulting plots fit into the specified paper size, that is, the paper length and the paper width, given the parameters controlling the plot, such as, the title information, the margin specifications, the rotation and scaling specifications and the maximum and minimum coordinate information.
GETIR	--	Determines the basic spacing index (IR) corresponding to a given radial coordinate value belonging to the list of radial coordinate spacing values (RSPACE).

TABLE 1. Continued.

GETJZ	--	Determines the basic spacing index (IZ) corresponding to a given axial coordinate value belonging to the list of axial coordinate spacing values (ZSPACE).
IJBCNO	--	Generates the element I-J grid maximum/minimum information from the nodal point I-J grid maximum/minimum information.
IJLIM	--	Determines the closest basic spacing data index I or J, given the value of a coordinate and the basic spacing dimension of that coordinate, i.e., given R and DI or Z and DJ.
IJSIZE	--	Initially determines the I-J grid information associated with the intersections of the fixed DI-DJ grid of the structural mesh and the outside and backside surfaces defined by the PAGAN input data. This determines the initial I-J grid maximum/minimum information associated with the structural finite element mesh.
INNUM	--	Encodes an integer number from internal format into equivalent alpha-numeric (I) format for plot annotation.
IRJZCK	--	Checks to see if a point defined by the indical values (IR,JZ) lies outside of the PAGAN mesh IG-JG grid.
KLOCK	--	Calls a system subroutine to determine the current elapsed central processor time.

TABLE 1. Continued.

KPLACE	--	Determines the location and word of a character for encoding integer and floating point numbers, as required by the subroutines INNUM and FPNUM.
LIMITS	--	Determines the maximum/minimum values of the two coordinate arrays X,Y.
MAKTRI	--	Changes a quadrilateral element into a compatible triangular element by renumbering the element's nodal point numbers to reflect the fact that one of them has been eliminated.
MINMAX	--	Determines the maximum and minimum I-J grid information for the structural finite element mesh.
MOUTCK	--	Checks to see if a element's (IC-JC) indices lie outside of the element I-J grid, thereby indicating that this element does not exist in the structural element mesh.
MXMN	--	Establishes the PAGAN mesh I-J grid maximum/minimum index information.
NMIJNP	--	Performs the actual function of checking the boundary surface elements to see if a given point (P,Q) lies inside one of them.
NODE	--	Determines the nodal point number (N), given its indices (I,J) on the nodal point I-J grid.

TABLE 1. Continued.

NODEIJ	--	Determines a nodal point's indices (I,J) on the nodal point I-J grid, given its nodal point number (N).
NOELEM	--	Returns the element number (M) given its indices (IC,JC) on the element I-J grid.
NORMAL	--	Calculates various geometrical quantities pertaining to the structural surfaces, e.g., surface line segment lengths, angular orientations and outward normal directions for both line segments and surface nodal points.
NOUTCK	--	Checks to see if a nodal point's (I,J) indices lie outside of the nodal point I-J grid, thereby indicating that this nodal point does not exist in the structural mesh.
NPLABL	--	Annotates the boundary of the finite element mesh with the list of boundary contour nodal point numbers, placed appropriately next to the nodal points on the boundary.
NPLOC	--	Determines the plot coordinate location of the number annotation, required by the subroutines NPLABL and ELLABL.
NPPRES	--	Generates the backside surface definition, that is, the nodal point numbers and the associated coordinate values of a plug or shell nose tip. The particular type of backside surface definition is determined by the user via an input option.

TABLE 1. Continued.

NSBLIM	--	Searches the boundary contour nodal point lists to determine the location and number of outside and backside surface nodal point numbers.
NSURNP	--	Checks to see if a given nodal point number (N) lies on the boundary surface, that is, whether it exists in the boundary surface nodal point number lists.
PGMESH	--	Main subroutine which controls the automatic generation of nose tip mesh. It calls subroutines to input the PAGAN data from a save tape and to automatically size the nose tip for a given element size. It sets up the nodal point I-J grid for the nose tip, and calculates the maximum/minimum I-J grid information associated with the nose tip. It fills in the interior R and Z coordinates for the nose tip and determines the element I-J grid for the nose tip. It generates the outside surface boundary contour nodal point lists. It checks for bad quadrilateral elements which might exist along the outside boundary of the nose tip, and if needed, smooths out these bad quadrilaterials by changing them into triangular elements. Finally, it prints out the results of the mesh generation.
PGPLOT	--	Main subroutine which controls the plotting of the final structural finite element mesh generated by PGMESH. It sizes the plot to fit onto a specified paper size, and also annotates the plot with either boundary contour nodal point or element numbers. It also plots the temperature field which was translated by PGTEMP by calling CONTOR.

TABLE 1. Continued.

PGPRES	--	Main subroutine which translates the nose tip pressure distribution given by the PAGAN input data to the generated structural finite element mesh. It translates the boundary pressures and temperatures for the outside surface boundary and calculates a reacting pressure distribution for the backside of the nose tip such that the resultant pressures acting on the nose tip are in static equilibrium.
PGTEMP	--	Main subroutine which translates the PAGAN mesh temperature field to the resultant structural finite element mesh. This translation process is performed by determining the temperature of the nodal points, and then averaging these nodal point values to determine the element temperatures.
PLTFN	--	Terminates the plotting sequence for a given set of plots.
PLTST	--	Initializes the plotting routines.
POESSY	--	Main driving program which calls the four sub-programs PGMESH, PGPRES, PGTEMP, PGPLOT, to perform the mesh generation, pressure translation, temperature translation, and plot the resulting mesh and/or temperature contours, respectively.
PSCALE	--	Automatically scales the axes of the plot, given the axis length of one coordinate direction and the maximum/minimum information of both coordinate directions.

QDRANT -- Determines the quadrant in which a line defined by the two incremental lengths DR and DZ, lies.

QUAD -- Interpolates the temperature of a point lying within a general triangular element.

QUADSZ -- Determines the aspect ratio associated with a quadraliteral finite element.

RCHECK -- Checks to see if a given radial coordinate R is equal to one of the basic spacing data points RSPACE.

RESULT -- Prints (and punches in DOASIS compatible format) the resultant structural finite element mesh.

ROUND -- Rounds a given floating point value to a specified number of digits.

RZPRIN -- Prints out the structural finite element mesh grid information that is, the radial and axial coordinates in 2-dimensional array form, the nodal point and element I-J grid maximum/minimum information, the list of boundary contour nodal point numbers and the list of outside and backside surface nodal point numbers along with their corresponding coordinate values.

SBIJMM -- Determines the I and J indices associated with the basic spacing data, RSPACE, ZSPACE and the limits of the R and Z coordinates.

TABLE 1. Continued.

SLOPE	--	Determines the constants A, B, C and D of the equations defining a line, that is, Z = A*R + B, or R = C*Z + D, when given the incremental values DR, DZ and RZ.
SMOOTH	--	Checks and smooths out the irregular boundary surface coordinates produced by the original sizing of the nose tip. Points which lie outside of the original surface are moved to the boundary surface in such a manner that the resulting quadrilateral and triangular elements lying along the surface form a smooth and even array of elements. Points that lie inside of the original boundary surface are similarily moved to the boundary surface locations to create meaningifully shaped elements comprising the final structural finite element mesh.
SORTR	--	Sorts the R and Z coordinate lists and (T) temperature list, according to decreasing values of R.
STOREA	--	Stores an alpha-numeric character into a computer word, given the position in the word.
SURBAK	--	Extracts from the boundary contour nodal point lists the list of outside and backside nodal point numbers and coordinates associated with the outside and backside pressure surface definitions, and loads the appropriate arrays with these numbers and coordinates.
SURFEL	--	Checks all of the boundary surface elements of the PAGAN mesh to see if a given point (P,Q) lies inside or on one of them. If so, it calls the appropriate subroutine to find the temperature of this given point (P,Q).

TABLE 1. Concluded.

SURPIJ	--	Performs three distinct functions; (1) it checks R and Z coordinate arrays and eliminates any points from these strings which are duplicates; (2) it checks the I and J indices associated with the surface nodal points to see if they are all included in the original strings, that is, to verify that all of the intersections of the interior mesh and the outside surface boundary are present; and (3) it assigns the I and J indical values to these surface nodal point strings which are used later in the solution sequence.
SYMLAB	--	Annotates the boundary contour with temperature value plot annotations, that is, symbols placed along the boundary which represent the different contour temperature values.
TITPLT	--	Plots title information on the plots, relative to the origin of the plot axes and rotation direction.
TRI	--	Interpolates the temperatures of a point lying within a general triangular element.
TRIANG	--	Eliminates a "triangular point" which lies either inside or outside of the boundary contour, in order to smooth out the resulting finite element mesh boundary surface elements.
TRISIZ	--	Determines the aspect ratio associated with a triangular finite element.
ZCHECK	--	Checks to see if a given axial coordinate Z is equal to the basic spacing data points ZSPACE.

SECTION VII

MODIFICATION OF PROGRAM SIZE

The size of the POESSY computer program is determined by three factors. First, the coding of the program which contains all locally dimensioned variables is basically fixed by the computer and compiler being used. Secondly, the computer being used also determines the size of the FORTRAN library functions and system routines needed to run POESSY. Thirdly, the size of the common blocks, used to store the solution variables, is determined by the user, depending upon the size of problems he wishes to solve.

All of the common blocks, and relevant data statements and dimension and equivalence statements are shown in Figure 10, along with the variables ISIZ, . . . , SSIZ. In order to change the size of the code, one simply has to change the size of these common blocks, dimension and equivalence statements in every routine in which they are contained. A cross-reference table to SUBROUTINE versus COMMON BLOCK is given in Figure 11. Therefore, the total size of core needed for all the variables contained in the common blocks is given by

```
LABELED COMMON  =  1128 + 4*ISIZ + 4*JSIZ + NBSIZ + 3*IGSIZ
                   + 3*JGSIZ + 6*MELSIZ + 4*NPSIZ + 5*PSIZ
                   + 10*SSIZ + 2*ISIZ*JSIZ + 3*IGSIZ*JGSIZ
```

where the meaning of ISIZ, . . . , SSIZ is given in Figure 10. For example, if the sizing is that shown in Figure 10, then the sizes of core would be

```
LABELED COMMON  =  22,478
```

The size of core needed for the code and system routines is given here for a Control Data Corporation CDC 6600 (Extended FORTRAN Compiler) running under the KRONOS 2.1 operating system, with core size for common blocks repeated from above.

	CODE	PLOT CODE	COMMON	SYSTEM	TOTAL
CDC 6600	23,262	2,191	22,478	7,537	33,053

Similar total core requirements may be expected from other computers.

```
 COMMON BLOCKS FOR PROGRAM POESSY(---)
****************************************

 INTEGER BUFFER
 COMMON/ELDATA/ IX(MELSIZ,5),BETA(NPSIZ)
 COMMON/IJGIVN/ IGMAX,JGMAX,IBEG(JGSIZ),IEND(JGSIZ),JBEG(IGSIZ),
1                JEND(IGSIZ)
 COMMON/IJMMEL/ ISTART(JCSIZ),IFINSH(JCSIZ),JSTART(ICSIZ),
1                JFINSH(ICSIZ),ILIM,JLIM,IJWAY,NSUR,NBAK,
2                NPNO(NBSIZ),NBN
 COMMON/IJMMNP/ IMIN(JSIZ),IMAX(JSIZ),JMIN(ISIZ),JMAX(ISIZ),MAXI,
1                MAXJ,NPWAY
 COMMON/INDATA/ NGSUR,RS(SSIZ),ZS(SSIZ),TS(SSIZ),PNS(SSIZ),
1                PTS(SSIZ),NGBAK,RB(SSIZ),ZB(SSIZ),TB(SSIZ),
2                RF(IGSIZ,JGSIZ),ZF(IGSIZ,JGSIZ),TF(IGSIZ,JGSIZ)
 COMMON/NPDATA/ DI,DJ,TRIFCT,R(ISIZ,JSIZ),Z(ISIZ,JSIZ),UR(NPSIZ),
1                UZ(NPSIZ)
 COMMON/NUMBAR/ ISHPLG,IWRIT,IPUNCH,IUSAVE,NUMNP,NUMEL,NUMPC,NUMTC
 COMMON/PLDATA/ ISCALE,IROTAT,IMARGN,IMXMN,IAXI,AXISPC,PPSPAC,
1                BORDER,PAPERL,PAPERW,RSTART,ZSTART,DELPU,RMINO,
2                RMAXO,ZMINO,ZMAXO,RMIN,RMAX,ZMIN,ZMAX,RLENG,
3                ZLENG,DELP
 COMMON/PLOTMC/ IPLOT,INBTYP,IORGCN,IANNOT,NCONT,TIME,ALTITD,
1                ITITLE(20),BUFFER(1024),INPAGN
 COMMON/SPACE/ NRSPC,NZSPC,RSPACE(IGSIZ),ZSPACE(JGSIZ),
1               NSCODE(SSIZ),NBCODE(SSIZ),ZBKWAL
 COMMON/SURPRS/ IBC(PSIZ),JBC(PSIZ),PNOR(PSIZ),PTAN(PSIZ)
 COMMON/SURTEM/ TSUR(PSIZ)
 COMMON/TEMDAT/ T(NPSIZ),TC(MELSIZ)
 COMMON/XYDATA/ XMIN,XMAX,DELX,YMIN,YMAX,DELY,AXMIN,AYMIN,XLENG,
1                YLENG,XTITL(2),YTITL(2),NXT,NYT,XA,YA,ANGX,ANGY,
2                XO,YO,ANGO,TILT,OMTILT,DELBOT,DELTOP,DELLFT,DELRGT


 THE DEFAULT VALUES PRESENTLY INCORPORATED INTO (POESSY) ARE GIVEN BY...


               ISIZ = 40                      MELSIZ = 600
               JSIZ = 60                       NBSIZ = 250
      ICSIZ = ISIZ-1 = 39                      NPSIZ = 700
      JCSIZ = JSIZ-1 = 59                       PSIZ = 200
              IGSIZ = 40                       PGSIZ = 1600
              JGSIZ = 60                        SSIZ = 100


 PRESET VARIABLE SIZING IS DONE IN THE FOLLOWING SUBROUTINE
**************************************************************


 SUBROUTINE IJBCNO(---)
 .
 .
 .
 DATA ISIZ/40/, JSIZ/60/, ICSIZ/39/, JCSIZ/59/, NBSIZ/250/,
1     IZERO/0/
```

Figure 10. Common Blocks, Dimensioning and Equivalencing Contained in POESSY Computer Program

```
DIMENSIONING AND EQUIVALENCING IS DONE IN THE FOLLOWING ROUTINES
*********************************************************************

(( EQUIVALENCING IS SHOWN FOR THE DEFAULT SIZES GIVEN ABOVE ))



 SUBROUTINE DATIN(---)
 DIMENSION RW(PGSIZ),ZW(PGSIZ),TW(PGSIZ),ISN(SSIZ),JSN(SSIZ),
1          IBN(SSIZ),JBN(SSIZ)
 .
 .
 .
 EQUIVALENCE (RW(1),R(1,1)), (ZW(1),R(40,41)), (TW(1),Z(40,21))
 EQUIVALENCE (ISN,IX(1,1)), (JSN,IX(101,1)), (IBN,IX(201,1)),
1             (JBN,IX(301,1))


 SUBROUTINE FILBAK(---)
 DIMENSION RW(1),ZW(1),TW(1),RE(SSIZ),ZE(SSIZ),TE(SSIZ)
 .
 .
 .
 EQUIVALENCE (RE(1),RF(1,1)), (ZE(1),ZF(1,1)), (TE(1),TF(1,1))


 SUBROUTINE RESULT
 DIMENSION NP(4),CODE(NPSIZ),CODE(NPSIZ)
 .
 .
 .
 EQUIVALENCE (CODSAV(1),Z(1701)), (CODE(1),BETA(1))


 SUBROUTINE DOSAVE(---)
 DIMENSION CODE(NPSIZ)
 .
 .
 .
 EQUIVALENCE (CODE(1),Z(1701))
```

Figure 10. Continued.

```
DIMENSIONING AND EQUIVALENCING (( CONTINUED ))
*************************************************


 1-    SUBROUTINE PGPRES
 2-    SUBROUTINE SURBAK(---)
 3-    SUBROUTINE NPPRES(---)

SUB = SUBROUTINE NUMBER WHICH CONTAINS FOLLOWING STATEMENTS . . . . . .

 1     DIMENSION XX(SSIZ)
 1     DIMENSION PHIS(SSIZ),PHIB(SSIZ),PHIGS(SSIZ),PHIGB(SSIZ),
 1   1           BETAS(SSIZ),BETAB(SSIZ),BETAGS(SSIZ),BETAGB(SSIZ)
ALL    DIMENSION RS(SSIZ),ZS(SSIZ),ANGS(SSIZ),SS(SSIZ),XS(SSIZ),AS(SSIZ),
ALL  1           PNS(SSIZ),PTS(SSIZ),PNSN(SSIZ),PTSN(SSIZ),RB(SSIZ),
ALL  2           ZB(SSIZ),ANGB(SSIZ),SB(SSIZ),XB(SSIZ),AB(SSIZ),PB(SSIZ),
ALL  3           PBN(SSIZ),ANGGS(SSIZ),SGS(SSIZ),XGS(SSIZ),AGS(SSIZ),
ALL  4           PGNSN(SSIZ),PGTSN(SSIZ),ANGGB(SSIZ),SGB(SSIZ),XGB(SSIZ),
ALL  5           AGB(SSIZ)
       .
       .
       .
ALL    EQUIVALENCE (RS,R(1)), (ZS,R(101)), (ANGS,R(201)), (SS,R(301)),
ALL  1             (XS,R(401)), (AS,R(501)), (PNS,R(601)), (PTS,R(701)),
ALL  2             (PNSN,R(801)), (PTSN,R(901)), (RB,R(1001)),
ALL  3             (ZB,R(1101)), (ANGB,R(1201)), (SB,R(1301)),
ALL  4             (XB,R(1401)), (AB,R(1501)), (PB,R(1601)),
ALL  5             (PBN,R(1701)), (ANGGS,R(1801)), (SGS,R(1901)),
ALL  6             (XGS,R(2001)), (AGS,R(2101)), (PGNSN,R(2201)),
ALL  7             (PGTSN,R(2301)), (ANGGB,Z(1)), (SGB,Z(101)),
ALL  8             (XGB,Z(201)), (AGB,Z(301))
 1     EQUIVALENCE (PHIS,Z(401)), (PHIB,Z(501)), (PHIGS,Z(601)),
 1   1             (PHIGB,Z(701)), (BETAS,Z(801)), (BETAB,Z(901)),
 1   2             (BETAGS,Z(1001)), (BETAGB,Z(1101)), (XX,Z(1201))



       SUBROUTINE PGPLOT(---)
       DIMENSION X(NBSIZ),Y(NBSIZ),XX(NPSIZ),YY(NPSIZ)
       .
       .
       .
       EQUIVALENCE (X(1),TF(1)), (Y(1),TF(251)), (XX(1),TF(501)),
     1             (YY(1),TF(1201))



       SUBROUTINE CONTUR
       DIMENSION HEAD(15),C(CSIZ),CX(NBSIZ),CY(NBSIZ),ANUM(3),XX(NPSIZ),
     1           YY(NPSIZ)
       .
       .
       .
       EQUIVALENCE (C(1),R(1)), (CX(1),R(51)), (CY(1),R(301)),
     1             (XX(1),R(1001)), (YY(1),R(1701))
```

Figure 10. Concluded.

```
C********************************************
C*            * E I I I I N N P P S S S T X *
C*            * L J J J N P U L L P U U E Y *
C*            * D G M M D D M D O A R R M D *
C*            * A I M M A A B A T C P I D A *
C*            * T V E N T T A T M E R E A T *
C*            * A N L P A A R A C   S M T A *
C********************************************
C*   POESSY   * X X X X X X X X X X X X X X *
C*   PGMESH   *     X X X X X               *
C*   DATIN    * X X X X X X X   X X         *
C*   FIXSPC   *         X         X         *
C*   FILBAK   *         X   X     X         *
C*   SORTR    *                             *
C*   RCHECK   *                   X         *
C*   ZCHECK   *                   X         *
C*   MXMN     *   X                         *
C*   SURPIJ   *             X               *
C*   SHIJMM   *                   X         *
C*   ELMSIZ   *         X X X               *
C*   ROUND    *                             *
C*   IJSIZE   *       X   X X               *
C*   IJLIM    *                             *
C*   QDRANT   *                             *
C*   SLOPE    *                             *
C*   MINMAX   *       X                     *
C*   NODEIJ   *       X                     *
C*   NODE     *       X                     *
C*   IJBCND   * X   X X     X               *
C*   CONNEC   * X   X       X               *
C*   NDELEM   *     X                       *
C*   NSBLIM   *     X X     X               *
C*   SMOOTH   *     X X   X X               *
C*   TRIANG   *           X X               *
C*   CORNER   *           X X               *
C*   FIXPNT   *           X                 *
C*   ELIMTP   * X         X X               *
C*   RZPRIN   *     X X   X                 *
C*   FIXSUR   *     X X     X               *
C*   FIXMM    *       X                     *
C*   ELEMNO   *                             *
C*   MODTCK   *     X                       *
C*   MAKTRI   * X           X               *
C*   RESULT   * X   X X   X X               *
C*   NODTCK   *       X                     *
C*   QUADSZ   *                             *
C*   TRISIZ   *                             *
C*   DOSAVE   * X   X X   X X       X   X   *
C********************************************
```

Figure 11. Cross Reference of Subroutines Versus Labeled Common Blocks for POESSY

```
C*************************************************
C*                * E I I I I N N P P S S S T X   *
C*                * L J J J N P O L L P U U E Y   *
C*                * D G M M D D M D G A R R M D   *
C*                * A I M M A A B A I C P T D A   *
C*                * T V E N T T A T M E R E A T   *
C*                * A N L P A A R A C   S M T A   *
C*************************************************
C*    PGPRES      *     X   X X X       X X       *
C*    SURBAR      *     X   X X           X       *
C*    NORMAL      *                               *
C*    FORCE       *                               *
C*    NPPRES      *     X   X X X     X   X       *
C*    PGTEMP      * X   X X X X X     X   X X     *
C*    NSURNP      *     X                         *
C*    FIND        *   X     X   X     X           *
C*    GETIR       *                   X           *
C*    GETJZ       *                   X           *
C*    IRJZCK      *   X                           *
C*    SURFEL      *   X     X   X                 *
C*    NMIJNP      *   X     X   X                 *
C*    ASPECT      *                               *
C*    ELEMCK      *                               *
C*    AREA        *                               *
C*    APEXEL      *   X     X   X     X           *
C*    TRI         *             X                 *
C*    QUAD        *             X                 *
C*    PGPLOT      *     X X X X X X X       X X   *
C*    PLTST       *               X               *
C*    PLTFN       *                               *
C*    LIMITS      *                               *
C*    PSCALE      *                               *
C*    FRAMIT      *               X           X   *
C*    NPLABL      *     X                     X   *
C*    ELLABL      *     X                     X   *
C*    NPLOC       *     X                     X   *
C*    BCELNO      * X           X                 *
C*    TITPLT      *                           X   *
C*    CONTOR      *     X X X X X X X       X X   *
C*    CONVAL      *                               *
C*    DRAW        *       X                   X   *
C*    SYMLAB      *     X     X   X         X X   *
C*    INNUM       *                               *
C*    FPNUM       *                               *
C*    KPLACE      *                               *
C*    STOREA      *                               *
C*    FETCHA      *                               *
C*    KLOCK       *                               *
C*    DASHLN      *                               *
C*************************************************
```

Figure 11. Concluded.

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXX
X                          X
X  USERS MANUAL FOR POESSY X
X                          X
XXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THE TAPE (OR FILE) ASSIGNMENTS ARE AS FOLLOWS ***

TAPE2 = INPUT DATA TAPE TO POESSY = OUTPUT DATA TAPE FROM PAGAN
TAPE3 = OUTPUT DATA TAPE FROM POESSY = INPUT DATA TAPE FOR DUASIS
TAPE5 = THE STANDARD INPUT FILE FOR READING CARDS
TAPE6 = THE STANDARD OUTPUT FILE FOR PRINTING
TAPE7 = CARD PUNCH FILE
TAPE9 = OUTPUT TAPE FOR PLOTTING (DRUM TYPE PLOTTERS)

THE POESSY CODE ONLY REQUIRES ONE CONTROL CARD FOR EACH SETUP DESIRED, AND TWO ADDITIONAL PLOT SCALLING CARDS IF PLOTS ARE MADE. THESE THREE CARDS ARE DESCRIBED BY THE FOLLOWING.

* CONTROL CARD FORMAT(9I5,3F10.0)

```
COLUMNS   1-5    NOCASE = CASE IDENTIFICATION NUMBER.
          6-10   ISHPLG = 0, PLUG TYPE OF NOSE TIP, WHERE THE REACTING
                             PRESSURE IS ASSUMED ACTING ON THE BUTT END
                             PORTION OF THE SHANK, IN THE Z-DIRECTION.
                        = 1, SHELL TYPE OF NOSE TIP, WHERE THE REACTING
                             PRESSURE IS ASSUMED TO ACT ON THE INSIDE
                             NOSE PORTION OF THE SHELL, FROM THE AXIS
                             OF REVOLUTION TO A POINT NEAR THE SPHERE-
                             CONE INTERSECTION POINT ON THE INSIDE.
                        = 2, SHELL TYPE OF NOSE TIP, WHERE THE REACTING
                             PRESSURE IS ASSUMED TO ACT ON THE BUTT END
                             OF THE CONE PORTION OF THE SHELL TIP.
          11-15  NSTEP = TIME STEP NUMBER OF THE PARTICULAR POINT IN
                         THE TRAJECTORY FOR WHICH THE MESH SETUP IS
                         DESIRED (THIS IS GIVEN FROM THE PAGAN SOLUTION)
```

```
16-20   IWRIT = PRINT OUT CONTROL PARAMETER.  THE POESSY CODE
                HAS SIX (6) DIFFERENT LEVELS OF PRINT OUT
                AVAILABLE, RANGING FROM IWRIT = 0 TO IWRIT = 5.
                THERE MEANING IS BRIEFLY AS FOLLOWS...
              = 0, PRINT INPUT CONTROL INFORMATION AND THE
                   SUMMARY OF THE OUTPUT CONTROL RESULTS.
              = 1, ADDITIONALLY, PRINT OUT THE NODAL POINT
                   COORDINATES, THE ELEMENT CONNECTIVITY
                   INFORMATION, THE PRESSURE CARD INFORMATION
                   AND THE ELEMENT TEMPERATURES.
              = 2, ADDITIONALLY PRINT OUT THE 1ST LEVEL OF
                   ADDITIONAL DIAGONISTIC DATA PERTAINING TO
                   INTERMEDIATE CALCULATIONS.
              = 3, ADDITIONALLY PRINT OUT THE 2ND LEVEL OF
                   ADDITIONAL DIAGONISTIC DATA PERTAINING TO
                   INTERMEDIATE CALCULATIONS.
              = 4, ADDITIONALLY PRINT OUT THE 3RD LEVEL OF
                   ADDITIONAL DIAGONISTIC DATA PERTAINING TO
                   INTERMEDIATE CALCULATIONS.
              = 5, ADDITIONALLY PRINT OUT THE HIGHEST LEVEL
                   ADDITIONAL DIAGONISTIC DATA PERTAINING TO
                   INTERMEDIATE CALCULATIONS.
21-25   IPUNCH = 0, DO NOT PUNCH OUT CARDS.
               = 1, PUNCH OUT THE MESH NODAL POINT CARDS, THE
                    ELEMENT CONNECTIVITY CARDS, THE PRESSURE
                    CARDS AND THE I-J N.P. AND ELEMENT GRID
                    CARDS.
26-30   IPLOT = 0, DO NOT PLOT ANYTHING,
              = 1, PLOT THE FINITE ELEMENT MESH,
              = 2, PLOT THE ISOTHERMS (CONTOUR PLOT),
              = 3, PLOT BOTH THE FINITE ELEMENT MESH AND
                   THE ISOTHERMS (CONTOUR PLOT).
31-35   IOSAVE = 0, SAVE NOTHING ON THE DATA SAVE TAPE = TAPE3.
               = 1, SAVE THE COMPLETE MESH DESCRIPTION ON THE
                    SAVE TAPE = TAPE3, IN THE DOASIS CODE
                    INPUT FORMAT.
36-40   NELEM = NUMBER OF ELEMENTS TO DIVIDE NOSE TIP INTO
                WHEN THE BASIC ELEMENT SIZE IS DETERMINED
                AUTOMATICALLY (SEE DISIZ AND DJSIZ).  THE
                FINAL NUMBER OF ELEMENTS CANNOT EXCEED 600,
                HENCE A TYPICAL VALUE = 550. IF NOTHING IS
                SPECIFIED, A DEFAULT VALUE = 400 IS USED.
41-45   INPAGN = 0, INPUT PAGAN CODE DATA FROM TAPE2 = PAGAN
                    CODE SAVE TAPE (NORMAL OPTION),
               = 1, INPUT PAGAN CODE DATA FROM CARDS (TAPE5).
46-55   DISIZ = BASIC SPACING DIMENSION FOR THE ELEMENT SIZE
                IN THE R-COORDINATE DIRECTION.
56-65   DJSIZ = BASIC SPACING DIMENSION FOR THE ELEMENT SIZE
                IN THE Z-COORDINATE DIRECTION.

                 ***** NOTICE *****, ONE MAY SPECIFY EITHER
                 DISIZ AND/OR DJSIZ TO PREDETERMINE THE BASIC
                 ELEMENT SIZING INFORMATION.  IF NEITHER IS
                 SPECIFIED, THEN THEY ARE DETERMINED BY THE
                 POESSY CODE BASED UPON DIVIDING THE NOSE TIP
                 INTO ((NELEM)) ELEMENTS, AUTOMATICALLY.
```

```
            66-75   TRIFCT = QUADRILATERAL ELEMENT REJECTION FACTOR, USED
                             TO DETERMINE IF THOSE ELEMENTS LYING ALONG THE
                             BOUNDARY CONTOUR HAVE BAD ASPECT RATIOS, AND
                             SHOULD BE CHANGED INTO TRIANGULAR ELEMENTS.
                             (THE DEFAULT VALUE OF TRIFCT = -135.00)

                             IF TRIFCT .GT. 0.0, THEN TRIFCT REPRESENTS
                             THE MAXIMUM ALLOWABLE HEIGHT TO BASE RATIO
                             OF A TRIANGLE FORMED FROM THE TWO BAD SIDES OF
                             QUADRILATERAL ELEMENT .  (TYPICAL VALUE = 0.1)

                             IF TRIFCT .LT. 0.0, THEN TRIFCT REPRESENTS
                             THE MAXIMUM ALLOWABLE ENCLOSED ANGLE EXISTING
                             AT THE NODAL POINT CONNECTING TO THE TWO BAD
                             SIDES OF THE ELEMENT. (TYPICAL VALUE = 135.00)


* PLOT SCALE CONTROL CARD     FORMAT(8I5/5F10.0)      (ONLY IF IPLOT .GT. 0)

    THIS CARD CONTROLS THE ROTATION AND SCALING OF THE PLOT.  EITHER FULLY
    AUTOMATIC PROGRAM CONTROL OR USER SUPPLIED CONTROL MAY BE USED.

      COLUMNS      1-5    ISCALE = 0, THE PROGRAM WILL AUTOMATICALLY SCALE THE
                                      COORDINATE DATA TO FIT THE ASSUMED PAPER
                                      DIMENSIONS (PAPERL AND PAPERW),
                                 = 1, THE USER WILL SUPPLY THE APPROPIATE
                                      SCALING INFORMATION (RSTART,ZSTART,DELPU).
                   6-10   IROTAT = -1, PLOT AXES WITH Z = X-AXIS DIRECTION
                                       (PAPER LENGTH DIRECTION = PAPERL)
                                 =  0, ROTATE THE AXES BASED UPON THE LONGER OF
                                       THE TWO AXES GOING IN THE LONGER OF THE
                                       TWO PAPER DIMENSIONS (LENGTH AND WIDTH)
                                 = +1, PLOT AXES WITH R = X-AXIS DIRECTION
                                       (PAPER LENGTH DIRECTION = PAPERL)
                  11-15   IMARGN = 0, DO NOT LEAVE A 1 INCH MARGIN BETWEEN THE
                                      BODY OF THE STRUCTURE AND THE AXES,
                                 = 1, LEAVE A 1 INCH MARGIN BETWEEN THEM.
                  16-20   IMXMN  = 0, IGNORE RSTART,ZSTART,DELPU (FOR ISCALE = 0)
                                 = 1, USE RSTART AS R-COORDINATE MINIMUM VALUE,
                                 = 2, USE ZSTART AS Z-COORDINATE MINIMUM VALUE,
                                 = 3, USE BOTH RSTART,ZSTART AS MINIMUMS.
                                      (RMIN AND/OR ZMIN ARE USED IF RSTART AND/OR
                                      ZSTART ARE NOT SPECIFIED)
                  21-25   INBTYP = 0, DO NOT ANNOTATE MESH PLOT.
                                 = 1, ANNOTATE THE MESH PLOT WITH THE BOUNDARY
                                      CONTOUR NODAL POINT NUMBERS, PLACED NEXT TO
                                      THEIR LOCATIONS OUTSIDE OF THE MESH.
                                 = 2, ANNOTATE THE MESH PLOT WITH THE BOUNDARY
                                      ELEMENT NUMBERS, PLACED NEXT TO THEIR
                                      LOCATIONS OUTSIDE OF THE MESH.
```

```
               26-30   IORGCN = 0, DO NOT PLOT THE INPUT BOUNDARY CONTOUR
                                    DEFINITION FROM THE PAGAN CODE.
                              = 1, PLOT THE INPUT BOUNDARY CONTOUR DEFINITION
                                    FROM THE PAGAN CODE, AS A DASHED LINE, WITH
                                    SYMBOLS AT THE I-J GRID INTERSECTIONS.
               31-35   IANNOT =  1, THE VALUES OF THE CONTOURS PLOTTED WILL
                                     BE LISTED ON THE PLOT,
                              =  0, DO NOT LIST ANY CONTOUR INFO. ON THE PLOT,
                              = -N, IN ADDITION TO LISTING THE VALUES OF THE
                                     CONTOURS ON THE PLOT, A SPECIAL SYMBOL IS
                                     USED TO ANNOTATE EACH (N-TH) CONTOUR ALONG
                                     THE BOUNDARY OF THE BODY, AND IS ALSO
                                     LISTED NEXT TO THE CONTOUR VALUE TABLE.
               36-40   NCONT = MINIMUM NUMBER OF ISOTHERMS (TEMPERATURE
                               CONTOURS) TO PLOT.  THE POESSY CODE DETERMINES
                               THE FINAL NUMBER AND VALUES OF THE CONTOURS
                               TO PLOT AUTOMATICALLY. HENCE, THE FINAL NUMBER
                               OF CONTOURS WILL BE .GE. TO NCONT AND .LE.
                               2*NCONT. (DEFAULT VALUE IS NCONT = 16).


* PLOT SCALE CONTROL CARD, CONTINUED      (SEE 1ST CARD FOR FORMAT)

     COLUMNS    1-10   PAPERL = GIVEN LENGTH OF PLOTTING PAPER FOR 1 PLOT,
                                I.E., ALONG THE ROLL OF THE PAPER,
               11-20   PAPERW = GIVEN WIDTH OF PLOTTING PAPER FOR 1 PLOT,
                                I.E., ACROSS THE ROLL OF THE PAPER.
               21-30   RSTART = MINIMUM VALUE OF THE R-COORDINATE FOR PLOTTING
                                THE R-AXIS.
               31-40   ZSTART = MINIMUM VALUE OF THE Z-COORDINATE FOR PLOTTING
                                THE Z-AXIS.
               41-50   DELPO = SCALE PARAMETER, WHERE 1 INCH OF PLOT LENGTH
                               EQUALS DELPO INCHES OF THE VARIABLES R,Z.
```

* PAGAN DATA INPUT CARDS   (ONLY IF INPAGN = 1)

THE FOLLOWING GROUP OF CARDS PROVIDES AN OPTION FOR INPUTTING THE PAGAN CODE OUTPUT DATA INTO POESSY VIA CARDS. THE PARTICULAR MEANING OF THE DIFFERENT VARIABLES DESCRIBED BELOW IS GIVEN IN THE PAGAN CODE USERS MANUAL, AND SHOULD BE CONSULTED FOR THEIR MEANING. A BRIEF DESCRIPTION WILL BE GIVEN HERE FOR CONVIENCE.

* PAGAN HEADING CARD   FORMAT(18A4)

COLUMNS 1-72   HEAD = 72 ALPHA/NUMERIC CHARACTERS OF TITLE INFORMATION

* PAGAN CONTROL CARD   FORMAT(2I5,F10.5,2F10.2,F10.5,5I5)

COLUMNS 1-5	NFILE	= FILE NUMBER OF DATA
6-10	NT	= TIME STEP NUMBER OF DATA
11-20	TIME	= ELASPSED TIME IN TRAJECTORY
21-30	ALTINF	= ALTITUDE IN TRAJECTORY
31-40	UINF	= NOSE TIP VELOCITY
41-50	STRECE	= CURRENT STAGNATION POINT RECCESION
51-55	KSURF	= NUMBER OF OUTSIDE SURFACE POINTS
56-60	NW	= TOTAL NUMBER OF COORDINATE AND TEMP POINTS
61-65	KBT	= NUMBER OF BACKSIDE SURFACE POINTS
66-70	IMAX1	= MAXIMUM AXIAL COORDINATE SPACING INDICY
71-75	JMAX1	= MAXIMUM RADIAL COORDINATE SPACING INDICY

* PAGAN COORDINATE SPACING DATA   FORMAT(5F16.12)

THE RADIAL AND AXIAL BASIC COORDINATE SPACING DATA ARE GIVEN, 5 TO A CARD, FOR (RSPACE(J),J=1,JMAX1) AND (ZSPACE(I),I=1,IMAX1) ACCORDING TO THE ABOVE FORMAT ON TWO SEPERATE SERIES OF CARDS. ANY CARD NOT FILLED IS LEFT BLANK FOR EACH SERIES. FOR EXAMPLE, FOR THE RSPACE(J) SERIES,

COLUMNS 1-16	RSPACE(1)	= 1ST RADIAL COORDINATE SPACING DATA
17-32	RSPACE(2)	= 2ND RADIAL COORDINATE SPACING DATA
33-48	RSPACE(3)	= 3RD RADIAL COORDINATE SPACING DATA
49-64		= AND SO ON . . . . .

* PAGAN DATA INPUT CARDS (CONTINUED) (ONLY IF INPAGN = 1)

* PAGAN OUTSIDE SURFACE POINT CARDS FORMAT(I5,5E15.5)

THE OUTSIDE SURFACE POINTS COORDINATES, TEMPERATURE AND PRESSURE DATA ARE GIVEN, ONE TO A CARD FOR (KSURF) POINTS ACCORDING TO THE ABOVE FORMAT.

COLUMNS	1-5	I = SURFACE NODAL POINT NUMBER
	6-20	ZW = AXIAL COORDINATE OF POINT
	21-35	RW = RADIAL COORDINATE OF POINT
	36-50	TW = TEMPERATURE OF POINT
	51-65	PNS = NORMAL PRESSURE ACTING AT POINT
	66-80	PTS = TANGENTIAL PRESSURE ACTING AT POINT

* PAGAN INTERIOR AND BACKSIDE SURFACE POINT CARDS FORMAT(I5,3E15.5)

THE INTERIOR AND BACKSIDE SURFACE POINTS COORDINATES AND TEMPERATURE DATA ARE GIVEN, ONE TO A CARD FOR (I = KSURF+1,...,NW) ACCORDING TO THE ABOVE FORMAT, WHERE THE NUMBERING CONTINUES FROM THE OUTSIDE SURFACE POINTS.

COLUMNS	1-5	I = INTERIOR OR BACKSIDE SURFACE NODAL POINT NUMBER
	6-20	ZW = AXIAL COORDINATE OF POINT
	21-35	RW = RADIAL COORDINATE OF POINT
	36-50	TW = TEMPERATURE OF POINT

NOTE, THE PAGAN NODAL POINT DATA IS GIVEN BASICALLY BY THE LAST TWO SERIES OF CARDS IN ONE LONG STRING, IN THE ORDER OF (1) OUTSIDE SURFACE POINTS, (2) INTERIOR POINTS AND (3) BACKSIDE SURFACE POINTS. THE PARTICULAR MEANING AND DISTRIBUTION ARE FULLY EXPLAINED IN THE PAGAN USERS MANUAL.

```
XXXXXXXXXXX
X  NOTES  X
XXXXXXXXXXX
```

PUESSY

XXXXXXXXXXXXXXXXXX
X COMMENT PAGE X
XXXXXXXXXXXXXXXXXX

WEILER RESEARCH INC. SOLICITS YOUR COMMENTS ABOUT THIS MANUAL WITH A VIEW TO IMPROVING ITS USEFULNESS IN LATER EDITIONS.

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WHAT IMPROVEMENTS DO YOU RECOMMEND TO BETTER SERVE YOUR PURPOSE

NOTE SPECIFIC ERRORS DISCOVERED (PLEASE INCLUDE PAGE NUMBER REFERENCE)

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APPENDIX A

SAMPLE PROBLEMS

SAMPLE PROBLEM NO. 1 (PLUG NOSE TIP)

The first sample problem choosen to illustrate the use of the POESSY program is a typical plug nose tip. This particular plug nose tip was analyzed over the complete trajectory by the PAGAN computer program (Reference 4). The particular point choosen to illustrate the use of the POESSY program was for time = 5.689 seconds, altitude = 57,600 feet. The PAGAN code mesh for this point in the trajectory is shown in Figure 6 .

The output from the PAGAN code was saved on a save tape and thus was used for input to POESSY, i.e., TAPE 2 in Figure 9 . Hence, only three cards were needed for input to POESSY. A complete description of the input data is given in the POESSY User's Manual, Section VIII of this manual. The input data cards for this plug nose tip sample problem are shown in Figure 12, where (Card 1) = Control Card and (Cards 2 and 3) = Plot Scale Control Cards.

One will notice that neither DISIZ or DJSIZ (Card 1, Columns 46-65) were specified but NELEM (Card 1, Columns 36-40) was specified = 175. Hence, the sizing of the basic rectangular element was performed automatically. The POESSY program printed output is shown in Figure 13. Here one can see that the automatic sizing of the basic rectangular element resulted in DI (=DR) = 0.230 and DJ (=DZ) = 0.230. This resulted in producing a final structural finite element mesh having 223 nodal points, 192 elements, 17 outside surface pressure boundary conditions and 6 backside reacting surface boundary conditions. The resultant structural finite element mesh is shown plotted (automatically by POESSY) in Figure 14, and the isotherm contour plot in Figure 15. The plot

scaling information for these plots is shown in the printed output in Figure 13, where the first set of scaling information applies to the mesh plot, the second to the isotherm contour plot. The little boxes shown plotted along the outside boundary of the mesh in Figure 14 represent the intersections of the PAGAN mesh with this boundary.

```
                          --- CARD COLUMNS ---

CARD           11111111112222222222333333333344444444445555555555666666666677777777778
 NO.  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1.     100     0    66     1     0     3     0   175     0        0.00        0.00        0.00
 2.       0     0     1     0     1     1    -2    16
 3.         14.0        11.0         0.0         0.0         1.0
```

```
                          --- CARD COLUMNS ---

CARD           11111111112222222222333333333344444444445555555555666666666677777777778
 NO.  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1.     126     2   126     1     0     3     0   150     0       0.150       0.275        0.00
 2.       0     0     1     0     1     1    -2    16
 3.         14.0        11.0         0.0         0.0         1.0
```

Figure 12. POESSY Input Data Cards for Sample Problems
(a) (Top) and (b) (Bottom)

```
PPPPPPPPPPP    OOOOOOOOOO   EEEEEEEEEEEE   SSSSSSSSSS    SSSSSSSSSS   YY        YY
PPPPPPPPPPPP  OOOOOOOOOOOO  EEEEEEEEEEEE  SSSSSSSSSSSS  SSSSSSSSSSSS  YY        YY
PP        PP  OO        OO  EE            SS        SS  SS        SS   YY      YY
PP        PP  OO        OO  EE            SS            SS               YY    YY
PP        PP  OO        OO  EE            SS            SS                YY  YY
PPPPPPPPPPPP  OO        OO  EEEEEEE       SSSSSSSSSSS   SSSSSSSSSSS        YYYY
PPPPPPPPPPP   OO        OO  EEEEEEE        SSSSSSSSSSS   SSSSSSSSSSS        YY
PP            OO        OO  EE                      SS            SS        YY
PP            OO        OO  EE                      SS            SS        YY
PP            OO        OO  EE            SS        SS  SS        SS        YY
PP            OOOOOOOOOOOO  EEEEEEEEEEEE  SSSSSSSSSSSS  SSSSSSSSSSSS        YY
PP             OOOOOOOOOO   EEEEEEEEEEEE   SSSSSSSSSS    SSSSSSSSSS         YY
```

```
                        CASE NUMBER (NOCASE) =   100
               SHELL/PLUG PARAMETER (ISHPLG) =     0
        REQUESTED TIME STEP NUMBER (NSTEP) =    66
              PRINT OUT PARAMETER (IWRIT) =     1
            PUNCH CARD PARAMETER (IPUNCH) =     0
                  PLOT PARAMETER (IPLOT) =     3
          SAVE RESULTS PARAMETER (IOSAVE) =     0
  TOTAL ELEMENTS IN MESH PARAMETER (NELEM) =   175
            DATA INPUT PARAMETER (INPAGN) =     0
    I-DIRECTION SPACING PARAMETER (DISIZ) =     0.0000000
    J-DIRECTION SPACING PARAMETER (DJSIZ) =     0.0000000
     BAD QUAD REJECTION PARAMETER (TRIFCT) =  -135.000
  BOUNDARY CONTOUR TYPE PARAMETER (INBTYP) =     1
  ORIGINAL CONTOUR PLOT PARAMETER (IORGCN) =     1
            ANNOTATION PARAMETER (IANNOT) =    -2
     NUMBER OF CONTOURS PARAMETER (NCONT) =    16
            MAXIMUM PAPER LENGTH (PAPERL) =        14.000
             MAXIMUM PAPER WIDTH (PAPERW) =        11.000
               SCALING PARAMETER (ISCALE) =     0
              ROTATION PARAMETER (IROTAT) =     0
           PLOT MARGIN PARAMETER (IMARGN) =     1
MINIMUM COORDINATE VALUE PARAMETER (IMXMN) =     0
    MINIMUM R COORDINATE VALUE (RSTART) =     0.000000
    MINIMUM Z COORDINATE VALUE (ZSTART) =     0.000000
      USER SUPPLIED SCALE FACTOR (DELPO) =     1.000000
```

Figure 13. POESSY Output for Sample Problem No. 1

```
THE FOLLOWING DATA PERTAINS TO THE DATA READ FROM THE PAGAN CODE SAVE TAPE

           TYPICAL PLUG NOSE TIP, SHALLOW TRAJECTORY, ATJ-S
     **********************************************************************

           ANALYSIS BY WEILER RESEARCH INC., MT. VIEW, CALIF.
     **********************************************************************


                 NFILE =     8
                    NT =    66
                  TIME =      5.689
                ALTINF =   57600.15
                  UINF =   19239.58
                STRECE =    .043010
                 KSURF =    27
                    NW =   240
                   KBT =    13
                 JMAX1 =    11
                 IMAX1 =    26


OUTSIDE SURFACE DATA FOR GIVEN TEMPERATURE MODEL
   N    I    J     RS(N)        ZS(N)        TS(N)

   1    1        0.0000000    6.4569900    7507.22
   2    2         .2000000    6.4469000    7519.89
   3    3         .4000000    6.4122200    7518.24
   4    4         .6000000    6.3540700    7390.48
   5        25    .7397040    6.3000000    7368.96
   6    5         .8000000    6.2732800    7347.98
   7    6        1.0000000    6.1640400    7203.02
   8        24   1.0928800    6.1000000    7127.40
```

Figure 13. Continued.

9	7		1,2000000	6,0127300	6987,69
10		23	1,3159700	5,9000000	6723,59
11	8		1,4000000	5,8028700	6494,43
12		22	1,4828800	5,7000000	6255,75
13	9		1,6000000	5,5223800	5510,91
14		21	1,6119900	5,5000000	5383,64
15		20	1,6978700	5,3000000	4496,86
16		19	1,7539100	5,1000000	3795,83
17		18	1,7878900	4,9000000	3070,95
18	10		1,8000000	4,8025300	2435,96
19		17	1,8123200	4,7000000	2110,06
20		16	1,8358700	4,5000000	1886,90
21		15	1,8593700	4,3000000	1792,91
22		14	1,8828600	4,1000000	1741,30
23		13	1,9063600	3,9000000	1707,91
24		12	1,9298500	3,7000000	1682,25
25		11	1,9533400	3,5000000	1661,05
26		10	1,9768400	3,3000000	1652,88
27			1,9827100	3,2500100	1652,88

BACKSIDE SURFACE DATA FOR GIVEN TEMPERATURE MODEL

N	I	J	RB(N)	ZB(N)	TB(N)
1			1,9827100	3,2500100	1652,88
2	10		1,8000000	3,1240000	1290,39
3		9	1,7580000	3,1000000	860,72
4	9		1,6000000	2,9877300	860,72
5		8	1,4560000	2,8675000	738,76
6	8		1,4000000	2,8474500	738,76
7	7		1,2000000	2,4791300	706,19
8		7	1,1980000	2,4750000	582,96
9		6	1,1980000	2,0625000	551,09
10		5	1,1980000	1,6500000	538,16
11		4	1,1980000	1,2375000	533,00
12		3	1,1980000	,8250000	531,05
13		2	1,1980000	,4125000	530,37
14		1	1,1980000	0,0000000	530,21
15	6	1	1,0000000	0,0000000	530,21
16	5	1	,8000000	0,0000000	530,21
17	4	1	,6000000	0,0000000	530,21
18	3	1	,4000000	0,0000000	530,21
19	2	1	,2000000	0,0000000	530,21
20	1	1	0,0000000	0,0000000	530,21

THE STATISTICS OF THE CURRENT NOSE TIP SHAPE ARE GIVEN BY

RGMAX = 1,982710 ZGMAX = 6,456990 CROSS-SECTION AREA = 9,3646628

THE SIZING OF THE BASIC RECTANGULAR ELEMENT BASED UPON THE AREA OF THE NOSE TIP IS GIVEN BY

APPROX, NO, OF ELEMENTS = 175 DI = ,230000 DJ = ,230000

Figure 13. Continued.

THE FOLLOWING IS THE NODAL POINT INFORMATION FOR THE GENERATED MESH

N	CODE	R(N)	Z(N)	N	CODE	R(N)	Z(N)
1	3.0	0.000000	0.000000	113	0.0	.690000	3.450000
2	0.0	.230000	0.000000	114	0.0	.920000	3.450000
3	0.0	.460000	0.000000	115	0.0	1.150000	3.450000
4	0.0	.690000	0.000000	116	0.0	1.380000	3.450000
5	0.0	.920000	0.000000	117	0.0	1.610000	3.450000
6	0.0	1.150000	0.000000	118	0.0	1.840000	3.450000
7	0.0	1.198000	0.000000	119	0.0	1.959215	3.450000
8	1.0	0.000000	.230000	120	1.0	0.000000	3.680000
9	0.0	.230000	.230000	121	0.0	.230000	3.680000
10	0.0	.460000	.230000	122	0.0	.460000	3.680000
11	0.0	.690000	.230000	123	0.0	.690000	3.680000
12	0.0	.920000	.230000	124	0.0	.920000	3.680000
13	0.0	1.150000	.230000	125	0.0	1.150000	3.680000
14	0.0	1.198000	.230000	126	0.0	1.380000	3.680000
15	1.0	0.000000	.460000	127	0.0	1.610000	3.680000
16	0.0	.230000	.460000	128	0.0	1.840000	3.680000
17	0.0	.460000	.460000	129	0.0	1.932199	3.680000
18	0.0	.690000	.460000	130	1.0	0.000000	3.910000
19	0.0	.920000	.460000	131	0.0	.230000	3.910000
20	0.0	1.150000	.460000	132	0.0	.460000	3.910000
21	0.0	1.198000	.460000	133	0.0	.690000	3.910000
22	1.0	0.000000	.690000	134	0.0	.920000	3.910000
23	0.0	.230000	.690000	135	0.0	1.150000	3.910000
24	0.0	.460000	.690000	136	0.0	1.380000	3.910000
25	0.0	.690000	.690000	137	0.0	1.610000	3.910000
26	0.0	.920000	.690000	138	0.0	1.840000	3.910000
27	0.0	1.150000	.690000	139	0.0	1.905185	3.910000
28	0.0	1.198000	.690000	140	1.0	0.000000	4.140000
29	1.0	0.000000	.920000	141	0.0	.230000	4.140000
30	0.0	.230000	.920000	142	0.0	.460000	4.140000
31	0.0	.460000	.920000	143	0.0	.690000	4.140000
32	0.0	.690000	.920000	144	0.0	.920000	4.140000
33	0.0	.920000	.920000	145	0.0	1.150000	4.140000
34	0.0	1.150000	.920000	146	0.0	1.380000	4.140000
35	0.0	1.198000	.920000	147	0.0	1.610000	4.140000
36	1.0	0.000000	1.150000	148	0.0	1.840000	4.140000
37	0.0	.230000	1.150000	149	0.0	1.878162	4.140000
38	0.0	.460000	1.150000	150	1.0	0.000000	4.370000
39	0.0	.690000	1.150000	151	0.0	.230000	4.370000
40	0.0	.920000	1.150000	152	0.0	.460000	4.370000
41	0.0	1.150000	1.150000	153	0.0	.690000	4.370000
42	0.0	1.198000	1.150000	154	0.0	.920000	4.370000
43	1.0	0.000000	1.380000	155	0.0	1.150000	4.370000
44	0.0	.230000	1.380000	156	0.0	1.380000	4.370000
45	0.0	.460000	1.380000	157	0.0	1.610000	4.370000
46	0.0	.690000	1.380000	158	0.0	1.850993	4.371292
47	0.0	.920000	1.380000	159	1.0	0.000000	4.600000
48	0.0	1.150000	1.380000	160	0.0	.230000	4.600000
49	0.0	1.198000	1.380000	161	0.0	.460000	4.600000
50	1.0	0.000000	1.610000	162	0.0	.690000	4.600000

Figure 13. Continued.

THE FOLLOWING IS THE NODAL POINT INFORMATION FOR THE GENERATED MESH

N	CODE	R(N)	Z(N)	N	CODE	R(N)	Z(N)
51	0.0	.230000	1.610000	163	0.0	.920000	4.600000
52	0.0	.460000	1.610000	164	0.0	1.150000	4.600000
53	0.0	.690000	1.610000	165	0.0	1.380000	4.600000
54	0.0	.920000	1.610000	166	0.0	1.610000	4.600000
55	0.0	1.150000	1.610000	167	0.0	1.624312	4.598154
56	0.0	1.198000	1.610000	168	1.0	0.000000	4.830000
57	1.0	0.000000	1.840000	169	0.0	.230000	4.830000
58	0.0	.230000	1.840000	170	0.0	.460000	4.830000
59	0.0	.460000	1.840000	171	0.0	.690000	4.830000
60	0.0	.690000	1.840000	172	0.0	.920000	4.830000
61	0.0	.920000	1.840000	173	0.0	1.150000	4.830000
62	0.0	1.150000	1.840000	174	0.0	1.380000	4.830000
63	0.0	1.198000	1.840000	175	0.0	1.610000	4.830000
64	1.0	0.000000	2.070000	176	0.0	1.796587	4.830000
65	0.0	.230000	2.070000	177	1.0	0.000000	5.060000
66	0.0	.460000	2.070000	178	0.0	.230000	5.060000
67	0.0	.690000	2.070000	179	0.0	.460000	5.060000
68	0.0	.920000	2.070000	180	0.0	.690000	5.060000
69	0.0	1.150000	2.070000	181	0.0	.920000	5.060000
70	0.0	1.198000	2.070000	182	0.0	1.150000	5.060000
71	1.0	0.000000	2.300000	183	0.0	1.380000	5.060000
72	0.0	.230000	2.300000	184	0.0	1.610000	5.060000
73	0.0	.460000	2.300000	185	0.0	1.760706	5.060000
74	0.0	.690000	2.300000	186	1.0	0.000000	5.290000
75	0.0	.920000	2.300000	187	0.0	.230000	5.290000
76	0.0	1.150000	2.300000	188	0.0	.460000	5.290000
77	0.0	1.198000	2.300000	189	0.0	.690000	5.290000
78	1.0	0.000000	2.530000	190	0.0	.920000	5.290000
79	0.0	.230000	2.530000	191	0.0	1.150000	5.290000
80	0.0	.460000	2.530000	192	0.0	1.380000	5.290000
81	0.0	.690000	2.530000	193	0.0	1.666841	5.322601
82	0.0	.920000	2.530000	194	1.0	0.000000	5.520000
83	0.0	1.150000	2.530000	195	0.0	.230000	5.520000
84	0.0	1.227623	2.530000	196	0.0	.460000	5.520000
85	1.0	0.000000	2.760000	197	0.0	.690000	5.520000
86	0.0	.230000	2.760000	198	0.0	.920000	5.520000
87	0.0	.460000	2.760000	199	0.0	1.150000	5.520000
88	0.0	.690000	2.760000	200	0.0	1.380000	5.520000
89	0.0	.920000	2.760000	201	0.0	1.603221	5.516568
90	0.0	1.150000	2.760000	202	1.0	0.000000	5.750000
91	0.0	1.358773	2.771526	203	0.0	.230000	5.750000
92	1.0	0.000000	2.990000	204	0.0	.460000	5.750000
93	0.0	.230000	2.990000	205	0.0	.690000	5.750000
94	0.0	.460000	2.990000	206	0.0	.920000	5.750000
95	0.0	.690000	2.990000	207	0.0	1.150000	5.750000
96	0.0	.920000	2.990000	208	0.0	1.417077	5.780760
97	0.0	1.150000	2.990000	209	1.0	0.000000	5.980000
98	0.0	1.467591	2.881015	210	0.0	.230000	5.980000
99	0.0	1.607717	2.993213	211	0.0	.460000	5.980000
100	1.0	0.000000	3.220000	212	0.0	.690000	5.980000

Figure 13. Continued.

THE FOLLOWING IS THE NODAL POINT INFORMATION FOR THE GENERATED MESH

N	CODE	R(N)	Z(N)	N	CODE	R(N)	Z(N)
101	0.0	.230000	3.220000	213	0.0	.920000	5.980000
102	0.0	.460000	3.220000	214	0.0	1.186456	6.021232
103	0.0	.690000	3.220000	215	1.0	0.000000	6.210000
104	0.0	.920000	3.220000	216	0.0	.230000	6.210000
105	0.0	1.150000	3.220000	217	0.0	.460000	6.210000
106	0.0	1.380000	3.220000	218	0.0	.732817	6.298528
107	0.0	1.610000	3.220000	219	0.0	.919048	6.208256
108	0.0	1.871974	3.173639	220	1.0	0.000000	6.440000
109	0.0	1.982783	3.249354	221	0.0	.230286	6.441646
110	1.0	0.000000	3.450000	222	0.0	.451068	6.396605
111	0.0	.230000	3.450000	223	1.0	0.000000	6.456990
112	0.0	.460000	3.450000	224	0.0	0.000000	0.000000

THE TOTAL INTEGRATED AREA OF THE FINAL MESH = 9.3604858E+00

Figure 13. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
1	1	2	9	8	1	0.00	1.000000	.056703	1.000000	
2	8	9	16	15	1	0.00	1.000000	.056703	1.000000	
3	15	16	23	22	1	0.00	1.000000	.056703	1.000000	
4	22	23	30	29	1	0.00	1.000000	.056703	1.000000	
5	29	30	37	36	1	0.00	1.000000	.056703	1.000000	
6	36	37	44	43	1	0.00	1.000000	.056703	1.000000	
7	43	44	51	50	1	0.00	1.000000	.056703	1.000000	
8	50	51	58	57	1	0.00	1.000000	.056703	1.000000	
9	57	58	65	64	1	0.00	1.000000	.056703	1.000000	
10	64	65	72	71	1	0.00	1.000000	.056703	1.000000	
11	71	72	79	78	1	0.00	1.000000	.056703	1.000000	
12	78	79	86	85	1	0.00	1.000000	.056703	1.000000	
13	85	86	93	92	1	0.00	1.000000	.056703	1.000000	
14	92	93	101	100	1	0.00	1.000000	.056703	1.000000	
15	100	101	111	110	1	0.00	1.000000	.056703	1.000000	
16	110	111	121	120	1	0.00	1.000000	.056703	1.000000	
17	120	121	131	130	1	0.00	1.000000	.056703	1.000000	
18	130	131	141	140	1	0.00	1.000000	.056703	1.000000	
19	140	141	151	150	1	0.00	1.000000	.056703	1.000000	
20	150	151	160	159	1	0.00	1.000000	.056703	1.000000	
21	159	160	169	168	1	0.00	1.000000	.056703	1.000000	
22	168	169	178	177	1	0.00	1.000000	.056703	1.000000	
23	177	178	187	186	1	0.00	1.000000	.056703	1.000000	
24	186	187	195	194	1	0.00	1.000000	.056703	1.000000	
25	194	195	203	202	1	0.00	1.000000	.056703	1.000000	
26	202	203	210	209	1	0.00	1.000000	.056703	1.000000	
27	209	210	216	215	1	0.00	1.000000	.056703	1.000000	
28	215	216	221	220	1	0.00	1.004205	.056977	1.007205	
29	220	221	223	223	1	0.00	.036981	.001400	7.050471	13.554199
30	2	3	10	9	1	0.00	1.000000	.170109	1.000000	
31	9	10	17	16	1	0.00	1.000000	.170109	1.000000	
32	16	17	24	23	1	0.00	1.000000	.170109	1.000000	
33	23	24	31	30	1	0.00	1.000000	.170109	1.000000	
34	30	31	38	37	1	0.00	1.000000	.170109	1.000000	
35	37	38	45	44	1	0.00	1.000000	.170109	1.000000	
36	44	45	52	51	1	0.00	1.000000	.170109	1.000000	
37	51	52	59	58	1	0.00	1.000000	.170109	1.000000	
38	58	59	66	65	1	0.00	1.000000	.170109	1.000000	
39	65	66	73	72	1	0.00	1.000000	.170109	1.000000	
40	72	73	80	79	1	0.00	1.000000	.170109	1.000000	
41	79	80	87	86	1	0.00	1.000000	.170109	1.000000	
42	86	87	94	93	1	0.00	1.000000	.170109	1.000000	
43	93	94	102	101	1	0.00	1.000000	.170109	1.000000	
44	101	102	112	111	1	0.00	1.000000	.170109	1.000000	
45	111	112	122	121	1	0.00	1.000000	.170109	1.000000	
46	121	122	132	131	1	0.00	1.000000	.170109	1.000000	
47	131	132	142	141	1	0.00	1.000000	.170109	1.000000	
48	141	142	152	151	1	0.00	1.000000	.170109	1.000000	
49	151	152	161	160	1	0.00	1.000000	.170109	1.000000	
50	160	161	170	169	1	0.00	1.000000	.170109	1.000000	

Figure 13. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
51	169	170	179	178	1	0.00	1.000000	.170109	1.000000	
52	178	179	188	187	1	0.00	1.000000	.170109	1.000000	
53	187	188	196	195	1	0.00	1.000000	.170109	1.000000	
54	195	196	204	203	1	0.00	1.000000	.170109	1.000000	
55	203	204	211	210	1	0.00	1.000000	.170109	1.000000	
56	210	211	217	216	1	0.00	1.000000	.170109	1.000000	
57	216	217	222	221	1	0.00	.889230	.150320	1.279415	
58	3	4	11	10	1	0.00	1.000000	.283515	1.000000	
59	10	11	18	17	1	0.00	1.000000	.283515	1.000000	
60	17	18	25	24	1	0.00	1.000000	.283515	1.000000	
61	24	25	32	31	1	0.00	1.000000	.283515	1.000000	
62	31	32	39	38	1	0.00	1.000000	.283515	1.000000	
63	38	39	46	45	1	0.00	1.000000	.283515	1.000000	
64	45	46	53	52	1	0.00	1.000000	.283515	1.000000	
65	52	53	60	59	1	0.00	1.000000	.283515	1.000000	
66	59	60	67	66	1	0.00	1.000000	.283515	1.000000	
67	66	67	74	73	1	0.00	1.000000	.283515	1.000000	
68	73	74	81	80	1	0.00	1.000000	.283515	1.000000	
69	80	81	88	87	1	0.00	1.000000	.283515	1.000000	
70	87	88	95	94	1	0.00	1.000000	.283515	1.000000	
71	94	95	103	102	1	0.00	1.000000	.283515	1.000000	
72	102	103	113	112	1	0.00	1.000000	.283515	1.000000	
73	112	113	123	122	1	0.00	1.000000	.283515	1.000000	
74	122	123	133	132	1	0.00	1.000000	.283515	1.000000	
75	132	133	143	142	1	0.00	1.000000	.283515	1.000000	
76	142	143	153	152	1	0.00	1.000000	.283515	1.000000	
77	152	153	162	161	1	0.00	1.000000	.283515	1.000000	
78	161	162	171	170	1	0.00	1.000000	.283515	1.000000	
79	170	171	180	179	1	0.00	1.000000	.283515	1.000000	
80	179	180	189	188	1	0.00	1.000000	.283515	1.000000	
81	188	189	197	196	1	0.00	1.000000	.283515	1.000000	
82	196	197	205	204	1	0.00	1.000000	.283515	1.000000	
83	204	205	212	211	1	0.00	1.000000	.283515	1.000000	
84	211	212	218	217	1	0.00	1.285534	.371253	1.549908	
85	217	218	222	222	1	0.00	.488641	.132024	1.154206	1.481281
86	4	5	12	11	1	0.00	1.000000	.396921	1.000000	
87	11	12	19	18	1	0.00	1.000000	.396921	1.000000	
88	18	19	26	25	1	0.00	1.000000	.396921	1.000000	
89	25	26	33	32	1	0.00	1.000000	.396921	1.000000	
90	32	33	40	39	1	0.00	1.000000	.396921	1.000000	
91	39	40	47	46	1	0.00	1.000000	.396921	1.000000	
92	46	47	54	53	1	0.00	1.000000	.396921	1.000000	
93	53	54	61	60	1	0.00	1.000000	.396921	1.000000	
94	60	61	68	67	1	0.00	1.000000	.396921	1.000000	
95	67	68	75	74	1	0.00	1.000000	.396921	1.000000	
96	74	75	82	81	1	0.00	1.000000	.396921	1.000000	
97	81	82	89	88	1	0.00	1.000000	.396921	1.000000	
98	88	89	96	95	1	0.00	1.000000	.396921	1.000000	
99	95	96	104	103	1	0.00	1.000000	.396921	1.000000	
100	103	104	114	113	1	0.00	1.000000	.396921	1.000000	

Figure 13. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
101	113	114	124	123	1	0.00	1.000000	.396921	1.000000	
102	123	124	134	133	1	0.00	1.000000	.396921	1.000000	
103	133	134	144	143	1	0.00	1.000000	.396921	1.000000	
104	143	144	154	153	1	0.00	1.000000	.396921	1.000000	
105	153	154	163	162	1	0.00	1.000000	.396921	1.000000	
106	162	163	172	171	1	0.00	1.000000	.396921	1.000000	
107	171	172	181	180	1	0.00	1.000000	.396921	1.000000	
108	180	181	190	189	1	0.00	1.000000	.396921	1.000000	
109	189	190	198	197	1	0.00	1.000000	.396921	1.000000	
110	197	198	206	205	1	0.00	1.000000	.396921	1.000000	
111	205	206	213	212	1	0.00	1.000000	.396921	1.000000	
112	212	213	219	218	1	0.00	1.093418	.434643	1.729297	
113	5	6	13	12	1	0.00	1.000000	.510327	1.000000	
114	12	13	20	19	1	0.00	1.000000	.510327	1.000000	
115	19	20	27	26	1	0.00	1.000000	.510327	1.000000	
116	26	27	34	33	1	0.00	1.000000	.510327	1.000000	
117	33	34	41	40	1	0.00	1.000000	.510327	1.000000	
118	40	41	48	47	1	0.00	1.000000	.510327	1.000000	
119	47	48	55	54	1	0.00	1.000000	.510327	1.000000	
120	54	55	62	61	1	0.00	1.000000	.510327	1.000000	
121	61	62	69	68	1	0.00	1.000000	.510327	1.000000	
122	68	69	76	75	1	0.00	1.000000	.510327	1.000000	
123	75	76	83	82	1	0.00	1.000000	.510327	1.000000	
124	82	83	90	89	1	0.00	1.000000	.510327	1.000000	
125	89	90	97	96	1	0.00	1.000000	.510327	1.000000	
126	96	97	105	104	1	0.00	1.000000	.510327	1.000000	
127	104	105	115	114	1	0.00	1.000000	.510327	1.000000	
128	114	115	125	124	1	0.00	1.000000	.510327	1.000000	
129	124	125	135	134	1	0.00	1.000000	.510327	1.000000	
130	134	135	145	144	1	0.00	1.000000	.510327	1.000000	
131	144	145	155	154	1	0.00	1.000000	.510327	1.000000	
132	154	155	164	163	1	0.00	1.000000	.510327	1.000000	
133	163	164	173	172	1	0.00	1.000000	.510327	1.000000	
134	172	173	182	181	1	0.00	1.000000	.510327	1.000000	
135	181	182	191	190	1	0.00	1.000000	.510327	1.000000	
136	190	191	199	198	1	0.00	1.000000	.510327	1.000000	
137	198	199	207	206	1	0.00	1.000000	.510327	1.000000	
138	206	207	214	213	1	0.00	1.168887	.601767	1.240667	
139	213	214	219	219	1	0.00	.575231	.286040	1.117259	1.168087
140	6	7	14	13	1	0.00	.208696	.120806	4.791667	
141	13	14	21	20	1	0.00	.208696	.120806	4.791667	
142	20	21	28	27	1	0.00	.208696	.120806	4.791667	
143	27	28	35	34	1	0.00	.208696	.120806	4.791667	
144	34	35	42	41	1	0.00	.208696	.120806	4.791667	
145	41	42	49	48	1	0.00	.208696	.120806	4.791667	
146	48	49	56	55	1	0.00	.208696	.120806	4.791667	
147	55	56	63	62	1	0.00	.208696	.120806	4.791667	
148	62	63	70	69	1	0.00	.208696	.120806	4.791667	
149	69	70	77	76	1	0.00	.208696	.120806	4.791667	
150	76	77	84	83	1	0.00	.273093	.159081	4.871151	

Figure 13. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
151	83	84	91	90	1	0.00	.651056	.380106	4.159844	
152	90	91	98	97	1	0.00	.894613	.565317	3.249696	
153	97	98	106	105	1	0.00	1.427339	.905669	1.823981	
154	105	106	116	115	1	0.00	1.000000	.623732	1.000000	
155	115	116	126	125	1	0.00	1.000000	.623732	1.000000	
156	125	126	136	135	1	0.00	1.000000	.623732	1.000000	
157	135	136	146	145	1	0.00	1.000000	.623732	1.000000	
158	145	146	156	155	1	0.00	1.000000	.623732	1.000000	
159	155	156	165	164	1	0.00	1.000000	.623732	1.000000	
160	164	165	174	173	1	0.00	1.000000	.623732	1.000000	
161	173	174	183	182	1	0.00	1.000000	.623732	1.000000	
162	182	183	192	191	1	0.00	1.000000	.623732	1.000000	
163	191	192	200	199	1	0.00	1.000000	.623732	1.000000	
164	199	200	208	207	1	0.00	1.147471	.720959	1.208226	
165	207	208	214	214	1	0.00	.674087	.415856	1.055126	.966749
166	98	99	107	106	1	0.00	1.034867	.773722	2.519039	
167	106	107	117	116	1	0.00	1.000000	.737138	1.000000	
168	116	117	127	126	1	0.00	1.000000	.737138	1.000000	
169	126	127	137	136	1	0.00	1.000000	.737138	1.000000	
170	136	137	147	146	1	0.00	1.000000	.737138	1.000000	
171	146	147	157	156	1	0.00	1.000000	.737138	1.000000	
172	156	157	166	165	1	0.00	1.000000	.737138	1.000000	
173	165	166	175	174	1	0.00	1.000000	.737138	1.000000	
174	174	175	184	183	1	0.00	1.000000	.737138	1.000000	
175	183	184	193	192	1	0.00	1.237916	.924241	1.450827	
176	192	193	201	200	1	0.00	1.072991	.800210	1.603938	
177	200	201	208	208	1	0.00	.551434	.398806	1.131104	1.170563
178	99	108	107	107	1	0.00	.562553	.470589	1.107514	1.157097
179	107	108	118	117	1	0.00	1.170295	1.000000	1.262424	
180	117	118	128	127	1	0.00	1.000000	.850544	1.000000	
181	127	128	138	137	1	0.00	1.000000	.850544	1.000000	
182	137	138	148	147	1	0.00	1.000000	.850544	1.000000	
183	147	148	158	157	1	0.00	1.026706	.874650	1.049277	
184	157	158	167	166	1	0.00	.982473	.835493	1.133410	
185	166	167	176	175	1	0.00	.874776	.737663	1.261679	
186	175	176	185	184	1	0.00	.733246	.612507	1.563293	
187	184	185	193	193	1	0.00	.374060	.310933	1.251657	1.742471
188	108	109	119	118	1	0.00	.538414	.507965	2.638801	
189	118	119	129	128	1	0.00	.459596	.428944	2.529022	
190	128	129	139	138	1	0.00	.342139	.317042	3.577094	
191	138	139	149	148	1	0.00	.224067	.206691	6.110135	
192	148	149	150	158	1	0.00	.083427	.070363	3.318901	6.060786

Figure 13. Continued.

PRESSURE BOUNDARY CONDITION CARDS

(OUTSIDE AND BACKSIDE SURFACES)

IBC	JBC	PNOR	PTAN
221	223	615.992	.079
222	221	591.023	.242
218	222	542.650	.382
219	218	481.517	.479
214	219	391.057	.564
208	214	285.998	.579
201	208	191.407	.514
193	201	113.773	.421
185	193	66.906	.307
176	185	41.766	.220
167	176	33.761	.180
158	167	32.209	.167
149	158	30.853	.160
139	149	29.581	.154
129	139	28.395	.148
119	129	27.290	.142
109	119	26.424	.138
6	7	716.017	0.000
5	6	716.017	0.000
4	5	716.017	0.000
3	4	716.017	0.000
2	3	716.017	0.000
1	2	716.017	0.000

Figure 13. Continued.

THE ELEMENT TEMPERATURES TC(M) ARE GIVEN BY

1	70.25	2	70.37	3	70.63	4	71.14	5	71.99	6	73.54
7	75.90	8	80.01	9	85.98	10	95.46	11	109.01	12	126.67
13	147.81	14	169.94	15	193.01	16	217.04	17	243.16	18	273.79
19	312.15	20	362.18	21	429.19	22	520.46	23	645.74	24	824.89
25	1102.27	26	1589.51	27	2662.88	28	5180.04	29	6949.31	30	70.25
31	70.37	32	70.63	33	71.14	34	72.00	35	73.56	36	75.96
37	80.18	38	86.33	39	96.28	40	110.76	41	130.10	42	153.43
43	177.50	44	202.23	45	227.62	46	254.83	47	286.48	48	326.08
49	377.93	50	447.80	51	543.32	52	674.76	53	864.11	54	1161.07
55	1697.85	56	2937.39	57	5433.27	58	70.25	59	70.37	60	70.63
61	71.15	62	72.01	63	73.61	64	76.06	65	80.44	66	86.69
67	97.69	68	113.97	69	136.91	70	164.96	71	193.13	72	221.30
73	249.49	74	278.92	75	312.61	76	354.73	77	410.41	78	466.34
79	590.86	80	735.61	81	947.93	82	1292.00	83	1956.40	84	3955.01
85	6011.95	86	70.25	87	70.37	88	70.63	89	71.16	90	72.03
91	73.66	92	76.16	93	80.70	94	87.48	95	99.30	96	118.12
97	147.30	98	183.72	99	218.78	100	252.67	101	285.53	102	318.48
103	355.38	104	401.60	105	463.75	106	550.00	107	670.09	108	838.89
109	1094.99	110	1540.98	111	2488.77	112	5001.84	113	70.25	114	70.37
115	70.64	116	71.16	117	72.04	118	73.08	119	76.21	120	80.86
121	87.82	122	100.32	123	122.08	124	161.08	125	212.24	126	257.95
127	300.89	128	341.17	129	379.33	130	420.95	131	473.42	132	545.59
133	648.72	134	795.82	135	1007.86	136	1351.59	137	2036.49	138	3799.83
139	5664.84	140	70.25	141	70.37	142	70.64	143	71.17	144	72.05
145	73.71	146	76.26	147	80.97	148	88.12	149	100.89	150	152.19
151	215.81	152	253.33	153	307.31	154	374.28	155	427.00	156	472.69
157	521.03	158	582.33	159	669.72	160	802.97	161	1002.41	162	1302.06
163	1659.50	164	3355.56	165	5165.36	166	401.94	167	495.44	168	567.03
169	622.19	170	680.17	171	754.95	172	868.60	173	1072.90	174	1412.94
175	2273.83	176	3394.96	177	4569.74	178	638.19	179	766.74	180	819.13
181	886.25	182	962.87	183	1071.88	184	1222.72	185	1550.60	186	2188.64
187	3103.75	188	1078.60	189	1096.53	190	1146.24	191	1208.95	192	1265.23

Figure 13. Continued.

```
THE PLOT SCALLING INFORMATION CALCULATED BY THE SUBROUTINE PSCALE(---) IS AS FOLLOWS

PAPER PLOT LENGTH =    1.187400E+01     PAPER PLOT WIDTH =     9.500000E+00     IMARGN =     1     IMXMN =     0

RMIN =    0.              RMAX =    1.982783E+00     ZMIN =    0.              ZMAX =    6.456990E+00

RLENG =    3.000000E+00     ZLENG =    9.000000E+00     DELP =    7.500000E-01     TILT =   1.0


THE PLOT SCALLING INFORMATION CALCULATED BY THE SUBROUTINE PSCALE(---) IS AS FOLLOWS

PAPER PLOT LENGTH =    1.161800E+01     PAPER PLOT WIDTH =     6.476000E+00     IMARGN =     1     IMXMN =     0

RMIN =    0.              RMAX =    1.982783E+00     ZMIN =    0.              ZMAX =    6.456990E+00

RLENG =    3.000000E+00     ZLENG =    9.000000E+00     DELP =    7.500000E-01     TILT =   1.0


     MAXIMUM VALUE OF TEMPERATURE IN THE ARRAY =     7.059640E+03

     MINIMUM VALUE OF TEMPERATURE IN THE ARRAY =     7.020600E+01

     INCREMENT OF TEMPERATURE FOR CONTOUR PLOTTING =     4.000000E+02

     THE VALUES OF THE CONTOURS (TOTAL NUMBER =   17) ARE GIVEN BY

        4.000000E+02   8.000000E+02   1.200000E+03   1.600000E+03   2.000000E+03   2.400000E+03

        2.800000E+03   3.200000E+03   3.600000E+03   4.000000E+03   4.400000E+03   4.800000E+03

        5.200000E+03   5.600000E+03   6.000000E+03   6.400000E+03   6.800000E+03
```

Figure 13. Continued.

```
THE FOLLOWING STATISTICS ARE FOR THE GENERATED NOSE TIP

                    NUMNP =   223
                    NUMEL =   192
                    NUMPC =    23
                     MAXI =    10
                     MAXJ =    30
                     ILIM =     9
                     JLIM =    29
                      NBN =    69

              TIME TO GENERATE THE FINITE ELEMENT MESH =     3.6820
 TIME TO TRANSLATE THE PRESSURES AND SURFACE TEMPERATURES =      .0520
  TIME TO TRANSLATE THE IN-DEPTH TEMPERATURE DISTRIBUTION =      .4070
     TIME TO ROLLOUT DATA ONTO THE DOASIS CODE SAVE TAPE =     0.0000
   TIME TO PLOT THE MESH AND/OR THE TEMPERATURE ISOTHERMS =     2.7220
```

Figure 13. Concluded.

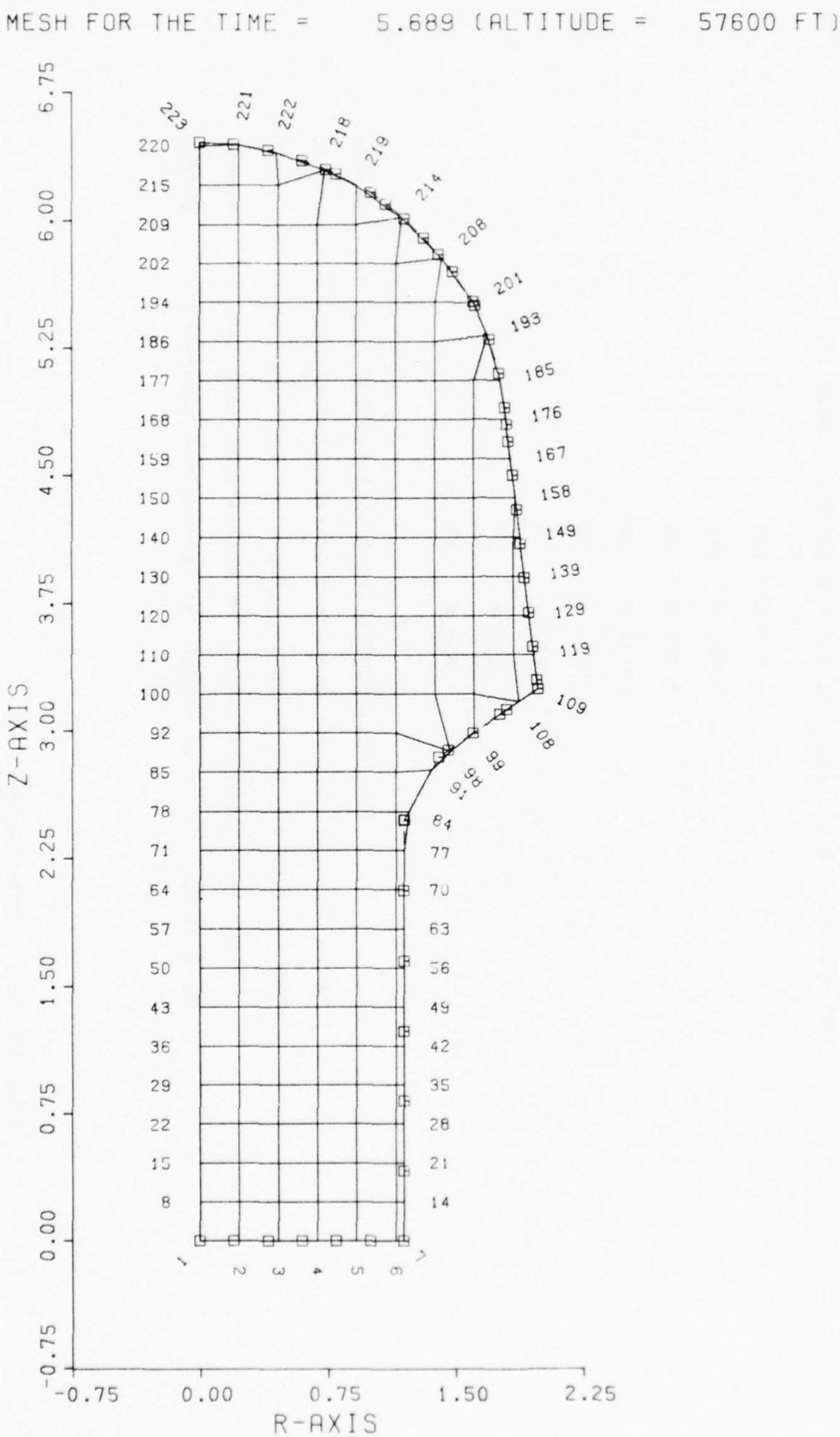

Figure 14. Finite Element Mesh for Sample Problem No. 1

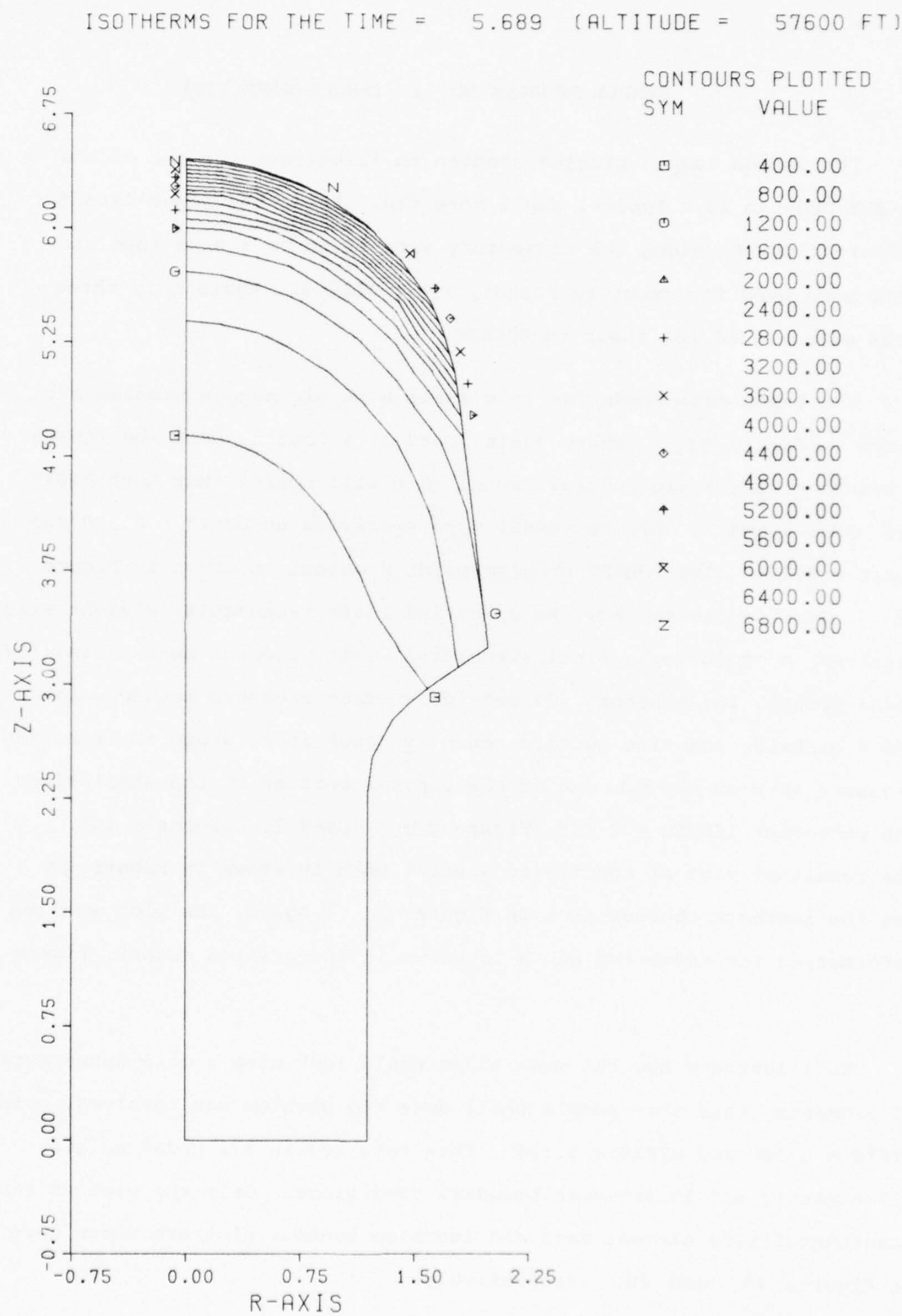

Figure 15. Isotherm Contour Plot of Sample Problem No. 1

SAMPLE PROBLEM NO. 2 (SHELL NOSE TIP)

The second sample problem choosen to illustrate the use of the POESSY program is a typical shell nose tip. Again the input data for different points along the trajectory were saved on a save tape and thus were used for input to POESSY, i.e., TAPE 2. Again only three cards were needed for input to POESSY.

The input data cards for this shell nose tip sample problem are shown in Figure 12, where again (Card 1) = Control Card and (Cards 2 and 3) = Plot Scale Control Cards. One will notice that both DISIZ and DJSIZ (Card 1, Columns 46-65) were specified as DISIZ = 0.150 and DJSIZ = 0.275. The POESSY program printed output is shown in Figure 16. Here we can see how the specified basic rectangular element size resulted in producing a final structural finite element mesh having 127 nodal points, 104 elements, 27 outside surface pressure boundary conditions and 4 backside reacting surface boundary conditions, where the reacting pressure acts on the butt end of the conical portion of the shell since the parameter ISHPLG = 2 (cf. Figure 12b, Card 1, Columns 6-10). The resultant plot of the finite element mesh is shown in Figure 17 and the isotherm contour plot in Figure 18. Again, the plot scaling information for these two plots is shown in the printed output, Figure 16.

To illustrate how the same shape would look with a more dense array of elements, this same sample shell nose tip problem was resolved, using DISIZ = 0.100 and DJSIZ = 0.124. This resulted in 372 nodal points, 327 elements and 59 pressure boundary conditions. Only the plot of the resultant finite element mesh and isotherm contour plot are shown here in Figures 19 and 20, respectively.

```
PPPPPPPPPPP    OOOOOOOOOO   EEEEEEEEEEEE   SSSSSSSSSS    SSSSSSSSSS   YY        YY
PPPPPPPPPPPP  OOOOOOOOOOOO  EEEEEEEEEEEE  SSSSSSSSSSSS  SSSSSSSSSSSS  YY        YY
PP        PP  OO        OO  EE            SS        SS  SS        SS   YY      YY
PP        PP  OO        OO  EE            SS            SS              YY    YY
PP        PP  OO        OO  EE            SS            SS               YY  YY
PPPPPPPPPPPP  OO        OO  EEEEEEEE      SSSSSSSSSSS   SSSSSSSSSSS       YYYY
PPPPPPPPPPP   OO        OO  EEEEEEEE       SSSSSSSSSSS   SSSSSSSSSSS       YY
PP            OO        OO  EE                      SS            SS       YY
PP            OO        OO  EE                      SS            SS       YY
PP            OO        OO  EE            SS        SS  SS        SS       YY
PP            OOOOOOOOOOOO  EEEEEEEEEEEE  SSSSSSSSSSSS  SSSSSSSSSSSS       YY
PP             OOOOOOOOOO   EEEEEEEEEEEE   SSSSSSSSSS    SSSSSSSSSS        YY

                           CASE NUMBER (NOCASE) =   126
                  SHELL/PLUG PARAMETER (ISHPLG) =     2
            REQUESTED TIME STEP NUMBER (NSTEP) =   126
                   PRINT OUT PARAMETER (IWRIT) =     1
                 PUNCH CARD PARAMETER (IPUNCH) =     0
                        PLOT PARAMETER (IPLOT) =     3
               SAVE RESULTS PARAMETER (IOSAVE) =     0
       TOTAL ELEMENTS IN MESH PARAMETER (NELEM) =   150
                 DATA INPUT PARAMETER (INPAGN) =     0
         I-DIRECTION SPACING PARAMETER (DISIZ) =      .1500000
         J-DIRECTION SPACING PARAMETER (DJSIZ) =      .2750000
          BAD QUAD REJECTION PARAMETER (TRIFCT) =     -135,000
        BOUNDARY CONTOUR TYPE PARAMETER (INBTYP) =     1
       ORIGINAL CONTOUR PLOT PARAMETER (IORGCN) =     1
                  ANNOTATION PARAMETER (IANNOT) =    -2
          NUMBER OF CONTOURS PARAMETER (NCONT) =    16
               MAXIMUM PAPER LENGTH (PAPERL) =         14,000
                MAXIMUM PAPER WIDTH (PAPERW) =         11,000
                    SCALING PAPAMETER (ISCALE) =     0
                   ROTATION PARAMETER (IROTAT) =     0
                 PLOT MARGIN PARAMETER (IMARGN) =     1
  MINIMUM COORDINATE VALUE PARAMETER (IMXMN) =     0
         MINIMUM R COORDINATE VALUE (RSTART) =     0,000000
         MINIMUM Z COORDINATE VALUE (ZSTART) =     0,000000
          USER SUPPLIED SCALE FACTOR (DELPO) =     1,000000
```

Figure 16.   POESSY Output for Sample Problem No. 2

THE FOLLOWING DATA PERTAINS TO THE DATA READ FROM THE PAGAN CODE SAVE TAPE

GENERAL ELECTRIC MOD-3A SHELL NOSE TIP, NTV3 TRAJECTORY
****

ANALYSIS BY WEILER RESEARCH INC., MT. VIEW, CALIF.
****

NFILE =	10
NT =	126
TIME =	7.513
ALTINF =	54326.00
UINF =	21006.00
STRECE =	.132710
KSURF =	43
NW =	211
KBT =	34
JMAX1 =	13
IMAX1 =	33

OUTSIDE SURFACE DATA FOR GIVEN TEMPERATURE MODEL

N	I	J	RS(N)	ZS(N)	TS(N)
1	1		0.0000000	6.0192900	8002.34
2	2	32	.1416540	6.0103500	8018.20
3	3		.2833080	5.9849500	7964.63
4	4		.4249620	5.9470100	7924.18
5	5		.5666160	5.8945400	7862.34
6		31	.6226370	5.8686900	7847.93
7	6		.7082690	5.8229600	7800.19
8		30	.8478720	5.7270400	7684.66

Figure 16. Continued.

9	7		.8499230	5.7254200	7682.20
10	8		.9915770	5.5866100	7431.83
11		29	.9943610	5.5853600	7424.46
12		28	1.0985000	5.4437300	7086.36
13	9		1.1332300	5.3827200	6846.06
14		27	1.1699100	5.3020600	6344.81
15		26	1.2141900	5.1604200	5569.93
16		25	1.2397800	5.0187700	4812.00
17		24	1.2577600	4.8771100	4301.45
18	10		1.2748800	4.7374400	3902.20
19		23	1.2809200	4.6862400	3761.53
20		22	1.3037300	4.4993700	3551.74
21		21	1.3263600	4.3105000	3478.76
22		20	1.3521100	4.0949700	3452.69
23		19	1.3778000	3.8794500	3447.91
24		18	1.4034900	3.6639200	3449.17
25		17	1.4291800	3.4484000	3420.44
26		16	1.4549300	3.2328800	3318.01
27	11		1.4637600	3.1599500	3170.77
28		15	1.4810400	3.0173500	2895.52
29		14	1.5068000	2.8018300	2793.05
30		13	1.5324200	2.5863000	2788.16
31		12	1.5580000	2.3707800	2811.16
32		11	1.5835700	2.1552500	2847.02
33		10	1.6091400	1.9397300	2881.35
34		9	1.6347900	1.7242000	2840.15
35	12		1.6526300	1.5762500	2628.97
36		8	1.6607900	1.5086800	2530.65
37		7	1.6864700	1.2931500	2481.76
38		6	1.7119700	1.0776300	2550.23
39		5	1.7374700	.8621000	2624.58
40		4	1.7629800	.6465750	2700.54
41		3	1.7864900	.4310500	2776.87
42		2	1.8140100	.2155250	2856.94
43		1	1.8395400	0.0000000	2940.91

BACKSIDE SURFACE DATA FOR GIVEN TEMPERATURE MODEL

N	I	J	RB(N)	ZB(N)	TB(N)
1		1	1.8395400	0.0000000	2940.91
2	12	1	1.6526300	0.0000000	2166.34
3	11	1	1.4637600	0.0000000	1947.21
4		1	1.4400000	0.0000000	1947.21
5		2	1.4077500	.2155250	1938.48
6		3	1.3755000	.4310500	1931.25
7		4	1.3432600	.6465750	1926.23
8		5	1.3106700	.8621000	1921.27
9		6	1.2772300	1.0776300	1911.60
10	10		1.2748800	1.0927400	1729.12
11		7	1.2437900	1.2931500	1729.12
12		8	1.2103400	1.5086800	1773.28
13		9	1.1769000	1.7242000	1863.46
14		10	1.1434600	1.9397300	1906.26
15	9		1.1332300	2.0056200	1784.48
16		11	1.1100100	2.1552500	1784.48

Figure 16. Continued.

17		12	1.0765700	2.3707800	1786.37
18		13	1.0431300	2.5863000	1803.36
19		14	1.0096800	2.8018300	1837.67
20	8		.9915770	2.9185000	1802.19
21		15	.9762390	3.0173500	1802.19
22		16	.9427950	3.2328800	1879.94
23		17	.9093520	3.4484000	1942.95
24		18	.8759080	3.6639200	1972.24
25	7		.8499230	3.7912300	1836.48
26		19	.8300740	3.8794500	1836.48
27		20	.7671070	4.0949700	1821.01
28	6		.7082690	4.2563300	1715.45
29		21	.6866000	4.3105000	1715.45
30		22	.6013140	4.4993700	1728.87
31	5		.5666160	4.5568300	1693.58
32		23	.4565080	4.6882400	1693.58
33	4		.4249620	4.7145300	1684.91
34	3		.2833080	4.8066400	1636.49
35	2		.1416540	4.8707000	1619.97
36		24	.1246830	4.8771100	1619.97
37	1		0.0000000	4.9020000	1668.96

THE STATISTICS OF THE CURRENT NOSE TIP SHAPE ARE GIVEN BY

RGMAX = 1.839540 ZGMAX = 6.019290 CROSS-SECTION AREA = 3.6382239

THE SIZING OF THE BASIC RECTANGULAR ELEMENT IS RETAINED FROM THE INITIAL SIZING AND IS GIVEN BY

DI = .150000 DJ = .275000 APPROXIMATE NO. OF ELEMENTS = 88

Figure 16. Continued.

THE FOLLOWING IS THE NODAL POINT INFORMATION FOR THE GENERATED MESH

N	CODE	R(N)	Z(N)	N	CODE	R(N)	Z(N)
1	0.0	1.440000	0.000000	65	0.0	.836700	3.850000
2	0.0	1.500000	0.000000	66	0.0	.900000	3.850000
3	0.0	1.650000	0.000000	67	0.0	1.050000	3.850000
4	0.0	1.800000	0.000000	68	0.0	1.200000	3.850000
5	2.0	1.839530	0.000000	69	0.0	1.360872	3.853080
6	0.0	1.398650	.275000	70	0.0	.755434	4.126982
7	0.0	1.500000	.275000	71	0.0	.900000	4.125000
8	0.0	1.650000	.275000	72	0.0	1.050000	4.125000
9	0.0	1.806871	.275814	73	0.0	1.200000	4.125000
10	0.0	1.357538	.551128	74	0.0	1.348543	4.124826
11	0.0	1.500000	.550000	75	0.0	.660641	4.364059
12	0.0	1.650000	.550000	76	0.0	.900000	4.400000
13	0.0	1.774764	.547015	77	0.0	1.050000	4.400000
14	0.0	1.317031	.820025	78	0.0	1.200000	4.400000
15	0.0	1.500000	.825000	79	0.0	1.315636	4.400000
16	0.0	1.650000	.825000	80	1.0	0.000000	4.902000
17	0.0	1.741661	.825000	81	0.0	.150000	4.866926
18	0.0	1.273754	1.100000	82	0.0	.300000	4.795786
19	0.0	1.350000	1.100000	83	0.0	.459316	4.683786
20	0.0	1.500000	1.100000	84	0.0	.516343	4.611144
21	0.0	1.650000	1.100000	85	0.0	.750000	4.675000
22	0.0	1.709323	1.100000	86	0.0	.900000	4.675000
23	0.0	1.230356	1.379711	87	0.0	1.050000	4.675000
24	0.0	1.350000	1.375000	88	0.0	1.200000	4.675000
25	0.0	1.500000	1.375000	89	0.0	1.282519	4.675000
26	0.0	1.676340	1.378155	90	1.0	0.000000	4.950000
27	0.0	1.188685	1.648244	91	0.0	.150000	4.950000
28	0.0	1.350000	1.650000	92	0.0	.300000	4.950000
29	0.0	1.500000	1.650000	93	0.0	.450000	4.950000
30	0.0	1.643827	1.649256	94	0.0	.600000	4.950000
31	0.0	1.145745	1.925000	95	0.0	.750000	4.950000
32	0.0	1.200000	1.925000	96	0.0	.900000	4.950000
33	0.0	1.350000	1.925000	97	0.0	1.050000	4.950000
34	0.0	1.500000	1.925000	98	0.0	1.246825	4.958879
35	0.0	1.610693	1.925000	99	1.0	0.000000	5.225000
36	0.0	1.103067	2.200000	100	0.0	.150000	5.225000
37	0.0	1.200000	2.200000	101	0.0	.300000	5.225000
38	0.0	1.350000	2.200000	102	0.0	.450000	5.225000
39	0.0	1.500000	2.200000	103	0.0	.600000	5.225000
40	0.0	1.578261	2.200000	104	0.0	.750000	5.225000
41	0.0	1.060155	2.476576	105	0.0	.900000	5.225000
42	0.0	1.200000	2.475000	106	0.0	1.050000	5.225000
43	0.0	1.350000	2.475000	107	0.0	1.194537	5.223292
44	0.0	1.500000	2.475000	108	1.0	0.000000	5.500000
45	0.0	1.545630	2.475000	109	0.0	.150000	5.500000
46	0.0	1.018483	2.745109	110	0.0	.300000	5.500000
47	0.0	1.200000	2.750000	111	0.0	.450000	5.500000
48	0.0	1.350000	2.750000	112	0.0	.600000	5.500000
49	0.0	1.512779	2.751523	113	0.0	.750000	5.500000
50	0.0	.975052	3.025000	114	0.0	.900000	5.500000

THE FOLLOWING IS THE NODAL POINT INFORMATION FOR THE GENERATED MESH

N	CODE	R(N)	Z(N)	N	CODE	R(N)	Z(N)
51	0.0	1.050000	3.025000	115	0.0	1.054629	5.503403
52	0.0	1.200000	3.025000	116	1.0	0.000000	5.775000
53	0.0	1.350000	3.025000	117	0.0	.150000	5.775000
54	0.0	1.480393	3.022655	118	0.0	.300000	5.775000
55	0.0	.931618	3.304906	119	0.0	.450000	5.775000
56	0.0	1.050000	3.300000	120	0.0	.600000	5.775000
57	0.0	1.200000	3.300000	121	0.0	.759009	5.768110
58	0.0	1.350000	3.300000	122	0.0	.852178	5.715475
59	0.0	1.446911	3.300000	123	1.0	0.000000	6.019290
60	0.0	.889948	3.573440	124	0.0	.150000	6.008653
61	0.0	1.050000	3.575000	125	0.0	.300000	5.980479
62	0.0	1.200000	3.575000	126	0.0	.450000	5.937736
63	0.0	1.350000	3.575000	127	0.0	.600000	5.879135
64	0.0	1.414089	3.575000	128	0.0	0.000000	0.000000

THE TOTAL INTEGRATED AREA OF THE FINAL MESH = 3.6359144E+00

Figure 16. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
1	80	81	91	90	1	0.00	.238317	.010105	3.295862	
2	90	91	100	99	1	0.00	1.000000	.042401	1.833333	
3	99	100	109	108	1	0.00	1.000000	.042401	1.833333	
4	108	109	117	116	1	0.00	1.000000	.042401	1.833333	
5	116	117	124	123	1	0.00	.869352	.036861	1.632537	
6	81	82	92	91	1	0.00	.431433	.054880	2.211743	
7	91	92	101	100	1	0.00	1.000000	.127203	1.833333	
8	100	101	110	109	1	0.00	1.000000	.127203	1.833333	
9	109	110	118	117	1	0.00	1.000000	.127203	1.833333	
10	117	118	125	124	1	0.00	.798787	.101608	1.586671	
11	82	83	93	92	1	0.00	.781628	.166781	2.226678	
12	92	93	102	101	1	0.00	1.000000	.212006	1.833333	
13	101	102	111	110	1	0.00	1.000000	.212006	1.833333	
14	110	111	119	118	1	0.00	1.000000	.212006	1.833333	
15	118	119	126	125	1	0.00	.669482	.141934	1.424393	
16	83	84	94	93	1	0.00	.791916	.226726	6.409866	
17	93	94	103	102	1	0.00	1.000000	.296808	1.833333	
18	102	103	112	111	1	0.00	1.000000	.296808	1.833333	
19	111	112	120	119	1	0.00	1.000000	.296808	1.833333	
20	119	120	127	126	1	0.00	.485220	.144017	1.677751	
21	75	65	84	84	1	0.00	.811482	.294681	1.065500	1.141022
22	84	85	95	94	1	0.00	1.394958	.515836	2.664381	
23	94	95	104	103	1	0.00	1.000000	.381610	1.833333	
24	103	104	113	112	1	0.00	1.000000	.381610	1.833333	
25	112	113	121	120	1	0.00	1.053666	.403508	1.934116	
26	120	121	127	127	1	0.00	.200709	.074097	1.240447	1.520946
27	60	66	65	65	1	0.00	.212196	.105035	2.502049	4.369039
28	65	66	71	70	1	0.00	.694406	.332922	4.772009	
29	70	71	76	75	1	0.00	1.211021	.550470	2.059964	
30	75	76	86	85	1	0.00	1.363210	.618601	2.371636	
31	85	86	96	95	1	0.00	1.000000	.466412	1.833333	
32	95	96	105	104	1	0.00	1.000000	.466412	1.833333	
33	104	105	114	113	1	0.00	1.000000	.466412	1.833333	
34	113	114	122	121	1	0.00	.725072	.334205	3.832177	
35	46	51	50	50	1	0.00	.254270	.145837	2.173500	3.734468
36	50	51	56	55	1	0.00	.648669	.367460	3.852656	
37	55	56	61	60	1	0.00	.916354	.507901	2.366015	
38	60	61	67	66	1	0.00	1.036341	.569774	1.846909	
39	66	67	72	71	1	0.00	1.000000	.551214	1.833333	
40	71	72	77	76	1	0.00	1.000000	.551214	1.833333	
41	76	77	87	86	1	0.00	1.000000	.551214	1.833333	
42	86	87	97	96	1	0.00	1.000000	.551214	1.833333	
43	96	97	106	105	1	0.00	1.000000	.551214	1.833333	
44	105	106	115	114	1	0.00	1.021618	.563799	1.857664	
45	114	115	122	122	1	0.00	.405835	.214663	1.492333	1.399622
46	27	32	31	31	1	0.00	.182003	.121225	2.852935	5.101053
47	31	32	37	36	1	0.00	.503959	.331126	5.190775	
48	36	37	42	41	1	0.00	.791112	.510230	2.927253	
49	41	42	47	46	1	0.00	1.059450	.670629	1.993482	
50	46	47	52	51	1	0.00	1.113950	.703528	1.896039	

Figure 16. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
51	51	52	57	56	1	0.00	1.000000	.636017	1.833333	
52	56	57	62	61	1	0.00	1.000000	.636017	1.833333	
53	61	62	68	67	1	0.00	1.000000	.636017	1.833333	
54	67	68	73	72	1	0.00	1.000000	.636017	1.833333	
55	72	73	78	77	1	0.00	1.000000	.636017	1.833333	
56	77	78	88	87	1	0.00	1.000000	.636017	1.833333	
57	87	88	98	97	1	0.00	1.172227	.753314	1.960583	
58	97	98	107	106	1	0.00	1.118245	.717759	1.944008	
59	106	107	115	115	1	0.00	.487649	.303309	1.431640	1.926278
60	14	19	18	18	1	0.00	.256752	.192159	2.142916	3.671978
61	18	19	24	23	1	0.00	.657521	.483482	3.782848	
62	23	24	28	27	1	0.00	.924772	.669082	2.340293	
63	27	28	33	32	1	0.00	1.040908	.748641	1.849053	
64	32	33	38	37	1	0.00	1.000000	.720819	1.833333	
65	37	38	43	42	1	0.00	1.000000	.720819	1.833333	
66	42	43	48	47	1	0.00	1.000000	.720819	1.833333	
67	47	48	53	52	1	0.00	1.000000	.720819	1.833333	
68	52	53	58	57	1	0.00	1.000000	.720819	1.833333	
69	57	58	63	62	1	0.00	1.000000	.720819	1.833333	
70	62	63	69	68	1	0.00	1.109597	.804660	1.885308	
71	68	69	74	73	1	0.00	1.091040	.790978	1.864688	
72	73	74	79	78	1	0.00	.880842	.650468	2.414022	
73	78	79	89	88	1	0.00	.660518	.466606	3.380896	
74	88	89	98	98	1	0.00	.283944	.199554	2.031214	3.440166
75	1	2	7	6	1	0.00	.537165	.443293	4.685957	
76	6	7	11	10	1	0.00	.813421	.661792	2.794399	
77	10	11	15	14	1	0.00	1.073681	.861121	1.954447	
78	14	15	20	19	1	0.00	1.118943	.896230	1.899160	
79	19	20	25	24	1	0.00	1.000000	.805621	1.833333	
80	24	25	29	28	1	0.00	1.000000	.805621	1.833333	
81	28	29	34	33	1	0.00	1.000000	.805621	1.833333	
82	33	34	39	38	1	0.00	1.000000	.805621	1.833333	
83	38	39	44	43	1	0.00	1.000000	.805621	1.833333	
84	43	44	49	48	1	0.00	1.045368	.844059	1.848307	
85	48	49	54	53	1	0.00	.970208	.780684	2.128566	
86	53	54	59	58	1	0.00	.760435	.604809	2.910363	
87	58	59	64	63	1	0.00	.536666	.421806	4.552011	
88	63	64	69	69	1	0.00	.216490	.169104	2.470787	4.348317
89	2	3	8	7	1	0.00	1.000000	.890423	1.833333	
90	7	8	12	11	1	0.00	1.000000	.890423	1.833333	
91	11	12	16	15	1	0.00	1.000000	.890423	1.833333	
92	15	16	21	20	1	0.00	1.000000	.890423	1.833333	
93	20	21	26	25	1	0.00	1.093536	.977781	1.874470	
94	25	26	30	29	1	0.00	1.060131	.946987	1.926918	
95	29	30	35	34	1	0.00	.850067	.751479	2.523645	
96	34	35	40	39	1	0.00	.630513	.551546	3.563363	
97	39	40	45	44	1	0.00	.412970	.357439	6.111569	
98	44	45	49	49	1	0.00	.152943	.131383	3.319012	6.060103
99	3	4	9	8	1	0.00	1.024384	1.000000	1.840161	
100	8	9	13	12	1	0.00	.931675	.906370	2.225655	

Figure 16. Continued.

ELEMENT CONNECTIVITY AND SIZING INFORMATION FOR THE GENERATED MESH

M	I	J	K	L	MATL	PHI(M)	AREA-RATIO	VOLUME-RATIO	RADIUS-RATIO	HEIGHT/BASE
101	12	13	17	16	1	0.00	.725412	.696892	3.078166	
102	16	17	22	21	1	0.00	.503946	.480864	4.700519	
103	21	22	26	26	1	0.00	.200013	.189806	2.637877	4.688804
104	4	5	9	9	1	0.00	.132157	.135642	3.778768	6.977324

Figure 16. Continued.

PRESSURE BOUNDARY CONDITION CARDS

(OUTSIDE AND BACKSIDE SURFACES)

IBC	JBC	PNOR	PTAN
124	123	859.731	.143
125	124	833.710	.356
126	125	791.381	.499
127	126	729.455	.642
121	127	633.259	.781
122	121	529.573	.886
115	122	384.560	.890
107	115	190.779	.692
98	107	73.745	.421
89	98	47.753	.293
79	89	44.085	.260
74	79	41.043	.242
69	74	38.370	.227
64	69	36.008	.214
59	64	33.977	.202
54	59	32.226	.193
49	54	30.538	.185
45	49	28.990	.176
40	45	27.716	.170
35	40	26.664	.163
30	35	25.911	.159
26	30	25.166	.157
22	26	24.254	.157
17	22	23.504	.156
13	17	22.927	.155
9	13	22.392	.155
5	9	21.876	.155
4	5	589.868	0.000
3	4	589.868	0.000
2	3	589.868	0.000
1	2	589.868	0.000

Figure 16. Continued.

THE ELEMENT TEMPERATURES TC(M) ARE GIVEN BY

1	1192.01	2	1332.94	3	1843.93	4	3143.32	5	5607.14	6	1188.95
7	1363.43	8	1924.38	9	3306.36	10	5905.92	11	1234.71	12	1449.39
13	2098.29	14	3646.32	15	6104.87	16	1299.89	17	1603.27	18	2397.81
19	4199.37	20	6433.45	21	1285.91	22	1422.63	23	1859.40	24	2878.94
25	5084.30	26	6853.48	27	1433.84	28	1387.06	29	1360.79	30	1414.62
31	1665.10	32	2278.25	33	3625.46	34	5899.33	35	1364.24	36	1415.65
37	1504.30	38	1524.20	39	1517.39	40	1500.52	41	1701.68	42	2062.00
43	2957.25	44	4751.84	45	6367.65	46	1421.02	47	1397.30	48	1357.14
49	1386.35	50	1433.25	51	1542.29	52	1683.01	53	1770.71	54	1846.31
55	1971.99	56	2219.00	57	2898.93	58	4097.08	59	5445.58	60	1390.06
61	1336.74	62	1370.17	63	1465.75	64	1497.60	65	1504.55	66	1561.55
67	1670.34	68	1899.89	69	2152.72	70	2373.03	71	2533.51	72	2635.72
73	2862.35	74	3398.37	75	1504.44	76	1498.76	77	1495.70	78	1487.99
79	1464.79	80	1528.55	81	1681.70	82	1780.41	83	1846.22	84	1963.78
85	2119.43	86	2411.78	87	2705.70	88	2852.91	89	1620.89	90	1633.88
91	1651.67	92	1670.59	93	1736.27	94	1902.36	95	2093.80	96	2187.03
97	2213.65	98	2263.43	99	2030.22	100	2033.88	101	2002.09	102	1972.93
103	1986.49	104	2390.78								

Figure 16. Continued.

```
THE PLOT SCALLING INFORMATION CALCULATED BY THE SUBROUTINE PSCALE(---) IS AS FOLLOWS
PAPER PLOT LENGTH =    1.187400E+01    PAPER PLOT WIDTH =    9.500000E+00    IMARGN =    1    IMXMN =    0
RMIN =    0.              RMAX =    1.839530E+00    ZMIN =    0.              ZMAX =    6.019290E+00
RLENG =    3.000000E+00    ZLENG =    9.000000E+00    DELP =    7.500000E-01    TILT =    1.0

THE PLOT SCALLING INFORMATION CALCULATED BY THE SUBROUTINE PSCALE(---) IS AS FOLLOWS
PAPER PLOT LENGTH =    1.161800E+01    PAPER PLOT WIDTH =    6.476000E+00    IMARGN =    1    IMXMN =    0
RMIN =    0.              RMAX =    1.839530E+00    ZMIN =    0.              ZMAX =    6.019290E+00
RLENG =    3.000000E+00    ZLENG =    9.000000E+00    DELP =    7.500000E-01    TILT =    1.0


    MAXIMUM VALUE OF TEMPERATURE IN THE ARRAY =    7.555017E+03
    MINIMUM VALUE OF TEMPERATURE IN THE ARRAY =    1.160913E+03
    INCREMENT OF TEMPERATURE FOR CONTOUR PLOTTING =    4.000000E+02

    THE VALUES OF THE CONTOURS (TOTAL NUMBER =   16) ARE GIVEN BY
       1.200000E+03   1.600000E+03   2.000000E+03   2.400000E+03   2.800000E+03   3.200000E+03
       3.600000E+03   4.000000E+03   4.400000E+03   4.800000E+03   5.200000E+03   5.600000E+03
       6.000000E+03   6.400000E+03   6.800000E+03   7.200000E+03
```

Figure 16. Continued.

```
THE FOLLOWING STATISTICS ARE FOR THE GENERATED NOSE TIP

                        NUMNP =   127
                        NUMEL =   104
                        NUMPC =    31
                         MAXI =    14
                         MAXJ =    23
                         ILIM =    13
                         JLIM =    22
                          NBN =    58

            TIME TO GENERATE THE FINITE ELEMENT MESH =      1.8540
 TIME TO TRANSLATE THE PRESSURES AND SURFACE TEMPERATURES =       .0660
  TIME TO TRANSLATE THE IN-DEPTH TEMPERATURE DISTRIBUTION =       .2700
       TIME TO ROLLOUT DATA ONTO THE DOASIS CODE SAVE TAPE =      0.0000
   TIME TO PLOT THE MESH AND/OR THE TEMPERATURE ISOTHERMS =      2.1660
```

Figure 16. Concluded.

MESH FOR THE TIME = 7.513 (ALTITUDE = 54326 FT)

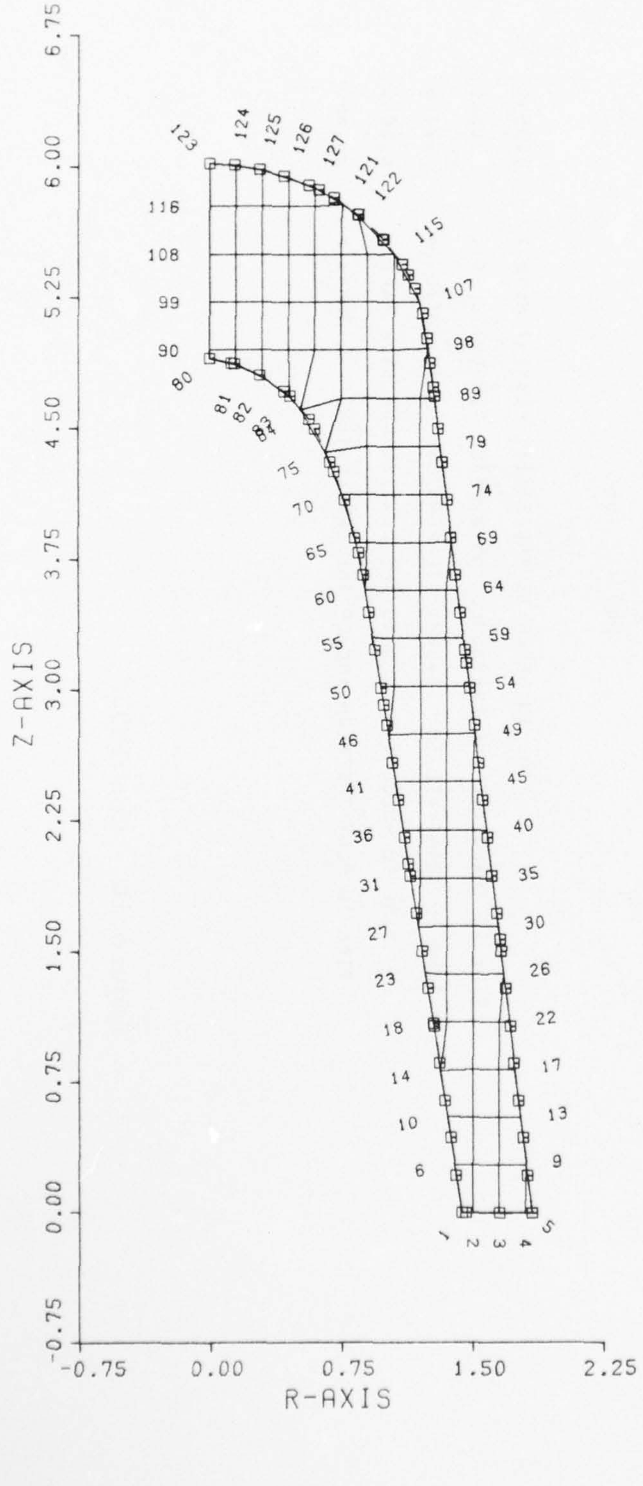

Figure 17. Coarse Mesh of Sample Problem No. 2

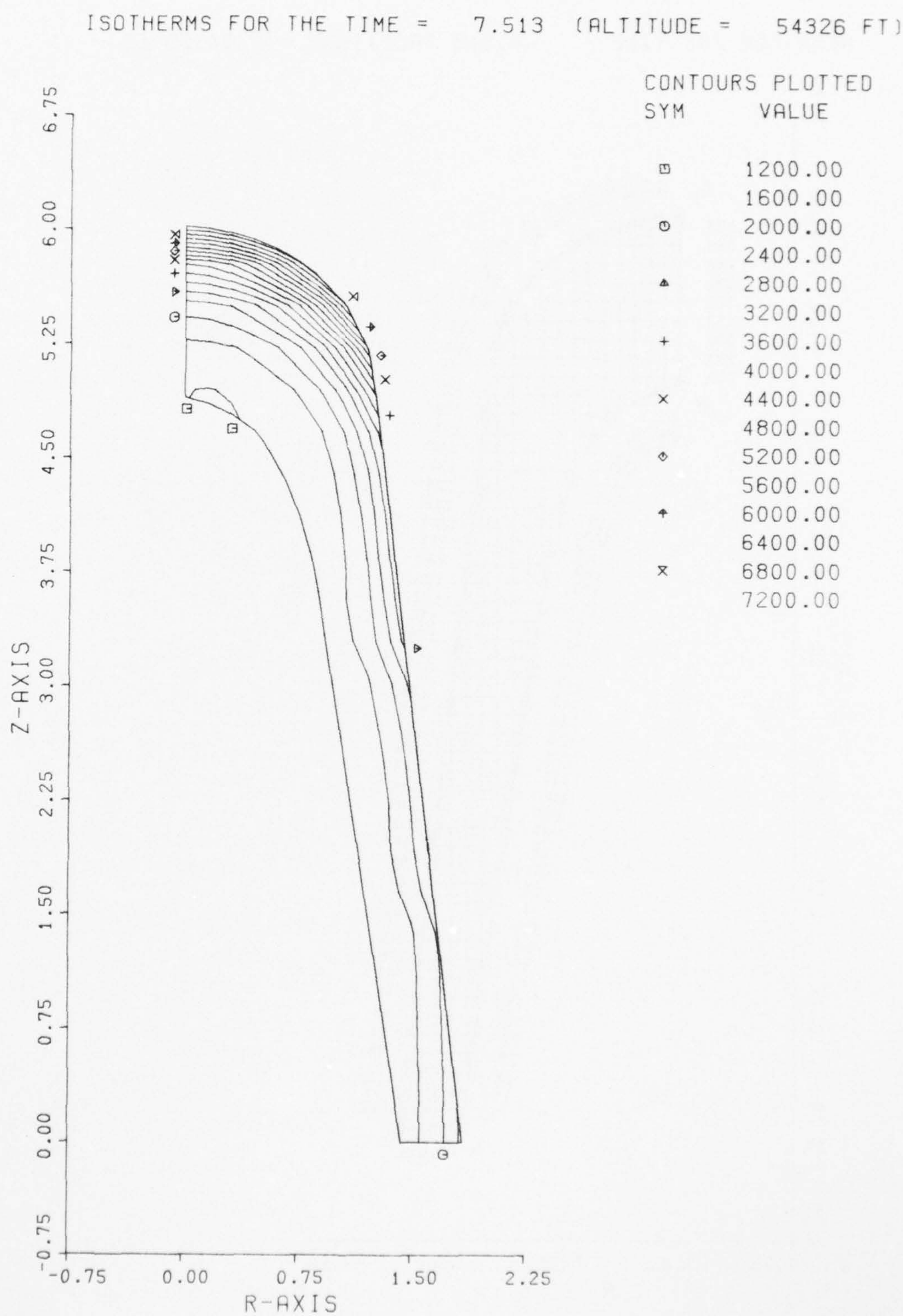

Figure 18. Coarse Mesh Isotherm Plot of Sample Problem No. 2

MESH FOR THE TIME = 7.513 (ALTITUDE = 54326 FT)

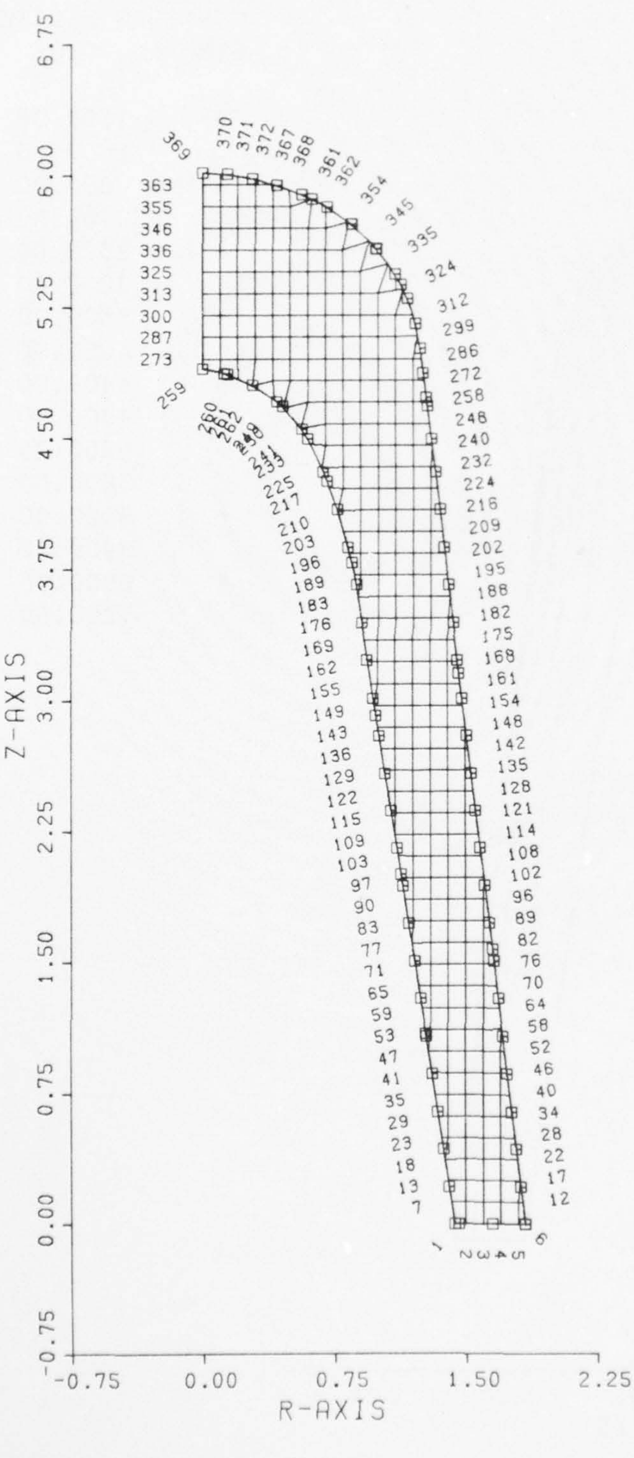

Figure 19. Refined Mesh of Sample Problem No. 2

AD-A031 008 WEILER RESEARCH INC MOUNTAIN VIEW CALIF F/G 16/3
POESSY, A COMPUTER PROGRAM FOR THE AUTOMATIC GENERATION OF REEN--ETC(U)
JUN 76 F C WEILER F33615-74-C-0193

UNCLASSIFIED AFML-TR-76-85 NL

2 OF 2
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DATE
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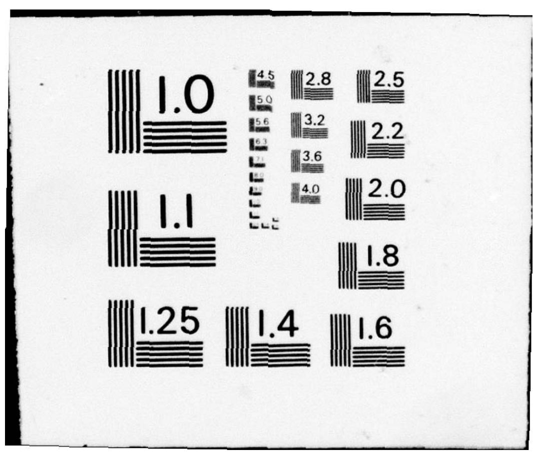
11 -76


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6

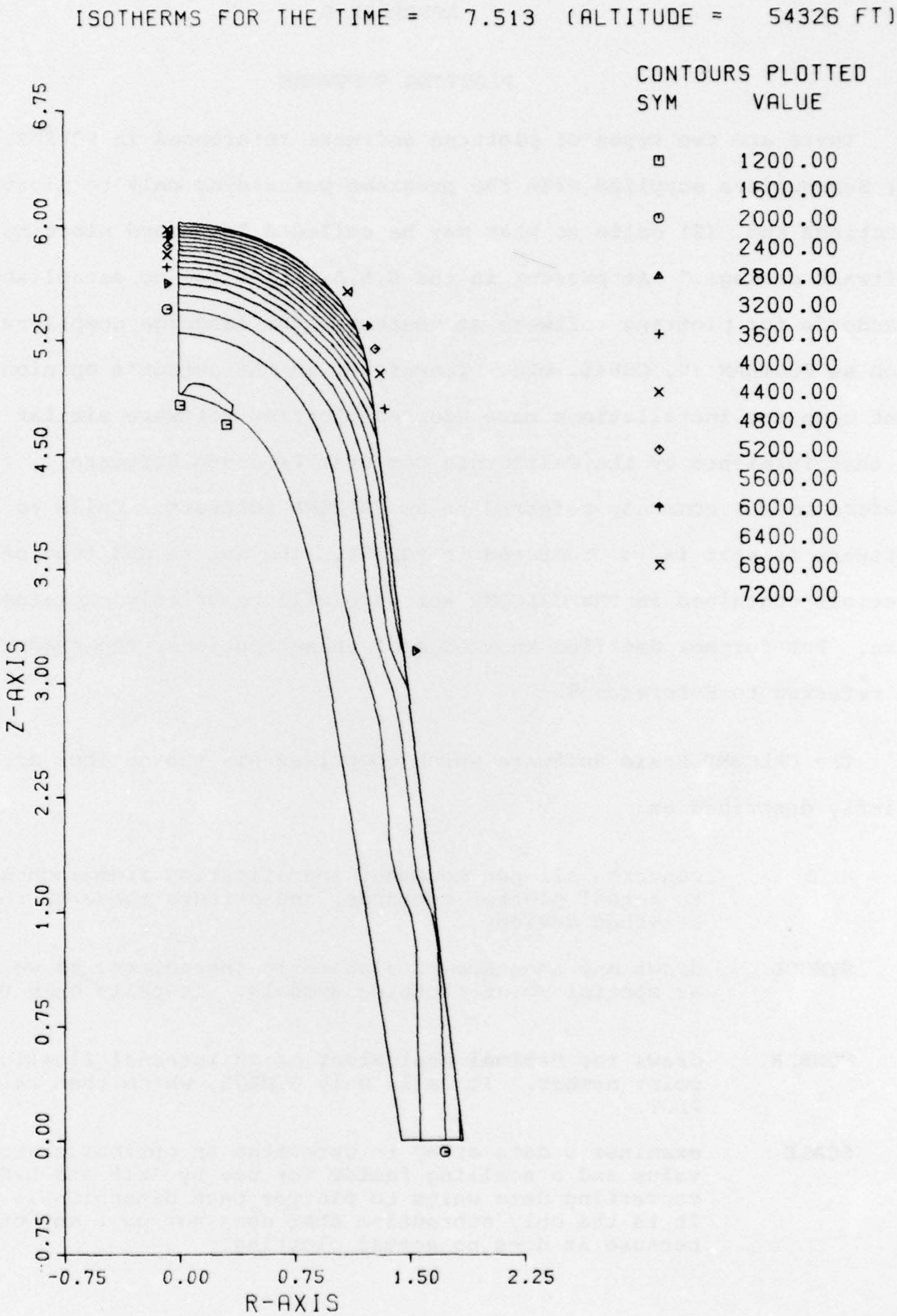


Figure 20. Refined Mesh Isotherm Plot of Sample Problem No. 2

APPENDIX B

PLOTTING SOFTWARE

There are two types of plotting software referenced in POESSY, (1) Subroutines supplied with the programs pertaining only to plotting functions and (2) calls to what may be called a "standard plotting software package." At present in the U.S.A. there are no established standards for plotting software as there are for language compilers such as FORTRAN IV, COBAL, etc. Therefore, in the author's opinion, most computer installations have adopted plotting software similar to or that furnished by the California Computer Products Software (Reference 5) commonly referred to as CALCOMP software. Calls to this software is what is incorporated in POESSY. The nature and type of routines contained in the CALCOMP software will be briefly explained here. For further detailed knowledge of these routines, the reader is referred to Reference 5.

The CALCOMP Basic Software which comprises six subroutines are briefly described as:

PLOT — converts all pen movement specification from inches to actual plotter commands, and outputs these to the attached device.

SYMBOL — draws any sequence of alphameric characters, as well as special point-plotting symbols. It calls only PLOT.

NUMBER — draws the decimal equivalent of an internal floating-point number. It calls only SYMBOL, which then calls PLOT.

SCALE — examines a data array to determine an optimum starting value and a scalling factor for use by AXIS and LINE in converting data units to plotter page dimensions. It is the only subroutine that does not call any other, because it does no actual plotting.

AXIS	draws an axis line with the appropriate scale annotation and title. It calls SYMBOL and NUMBER as well as PLOT.
LINE	plots a series of scalled data points defined by two arrays (X and Y), connecting the points with straight lines if desired. It may call SYMBOL as well as PLOT.

and the actual FORTRAN calls to these routines is given by

```
CALL PLOT(XPAGE,YPAGE,IPEN)

CALL PLOTS(BUFFER,NBUF,ITAPE)        *** ENTRY POINT IN PLOT (---) ***
CALL FACTOR(FACT)                    *** ENTRY POINT IN PLOT (---) ***
CALL WHERE(XPAGE,YPAGE,FACT)         *** ENTRY POINT IN PLOT (---) ***

CALL SYMBOL (XPAGE,YPAGE,HEIGHT,IBCD,ANGLE,NCHAR)

CALL SYMBOL(XPAGE,YPAGE,HEIGHT,ISYMNO,ANGLE,-ICODE)

CALL NUMBER (XPAGE,YPAGE,HEIGHT,FPNO,ANGLE,NDEC)

CALL SCALE (ARRAY, AXLENG,NPTS,INC)

CALL AXIS (XPAGE,YPAGE,IBCD,NCHAR,AXLENG,ANGLE,FIRSTV,DELTAV)

CALL LINE (XARRAY,YARRAY,NPTS,INC,LINTYP,ISYMNO)
```

Again, if the user's plotting software differs from that illustrated here, he is referred to Reference 5 to fully understand the meaning of all of the arguments in the calls to the CALCOMP software. The user can then make the appropriate changes in POESSY so that it will be compatible with his plotting software.

The subroutines supplied with POESSY that pertain strictly to operations associated with plotting are described by

PLTST PLTFN	initializes and terminates respectively the procedure by calling appropriate CALCOMP routines.

DASHLN	plots a series of scalled data points defined by two arrays (X and Y), connecting the points with a continuous dashed line of length specified by the user (DASH). It may call SYMBOL as well as PLOT.
TITPLT	plots a series of characters (in A4 format) comprising a title, given the coordinates of the start of the title and appropriate orientation and spacing parameters. It calls only SYMBOL which then calls PLOT.
NPLABL ELLABL (NPLOC)	annotates a boundary contour line defined by a series of contiguous nodal points (NPLABL) or a series of element sides (ELLABL) with the appropriate nodal point or element number, placed next to the point or line they are describing. They call auxiliarly routines NPLOC and INNUM as well as SYMBOL, WHERE (PLOT entry) and PLOT.
FRAMIT	determines all of the required sizing and scalling data necessary to fit a plot onto a specified paper size (length and width), given the parameters controlling the plot, such as, title information, margin specifications, rotation and scaling specifications and maximum and minimum coordinate values of the points defining the plot. It calls an auxiliary routine PSCALE, which scales both axis of the plot producing the axes lengths, starting values and a scale factor for use by AXIS.
INNUM FPNUM (KPLACE) (STOREA)	changes an integer or floating-point number from internal computer based format into alpameric format in the forms Im (INNUM) and Fm.n (FPNUM) following standard FORTRAN output conventions. They call auxiliary routines KPLACE which locates the word and position in the resulting alphameric character string and STOREA which stores a character in a computer word.

The type of annotation (numbering) performed by the subroutines NPLABL and ELLABL is shown graphically in Figure 21. One will notice that the element numbering is placed at the mid-point along the element's side. Also, the nodal point numbering is orientated by the average of the outward normals of the two connecting sides. The dashed lines in Figure 21 are only included to illustrate the spacing and are not drawn by the subroutines NPLABL and ELLABL. The rest of the subroutines are self-explanatory, with sufficient comment cards included in the coding to explain the meaning of all operations.

If a user does not have access to the Basic CALCOMP Software, he may (a) easily change all of the calls to this software to appropriate calls to his own plotting software which performs the same functions or (b) simulate the CALCOMP routines with dummy subroutines which then call his appropriate software. The author apologizes for the fact that no standards exist for plotting software, however he feels that the CALCOMP Basic Software comes the closest to all those being used at the present time.

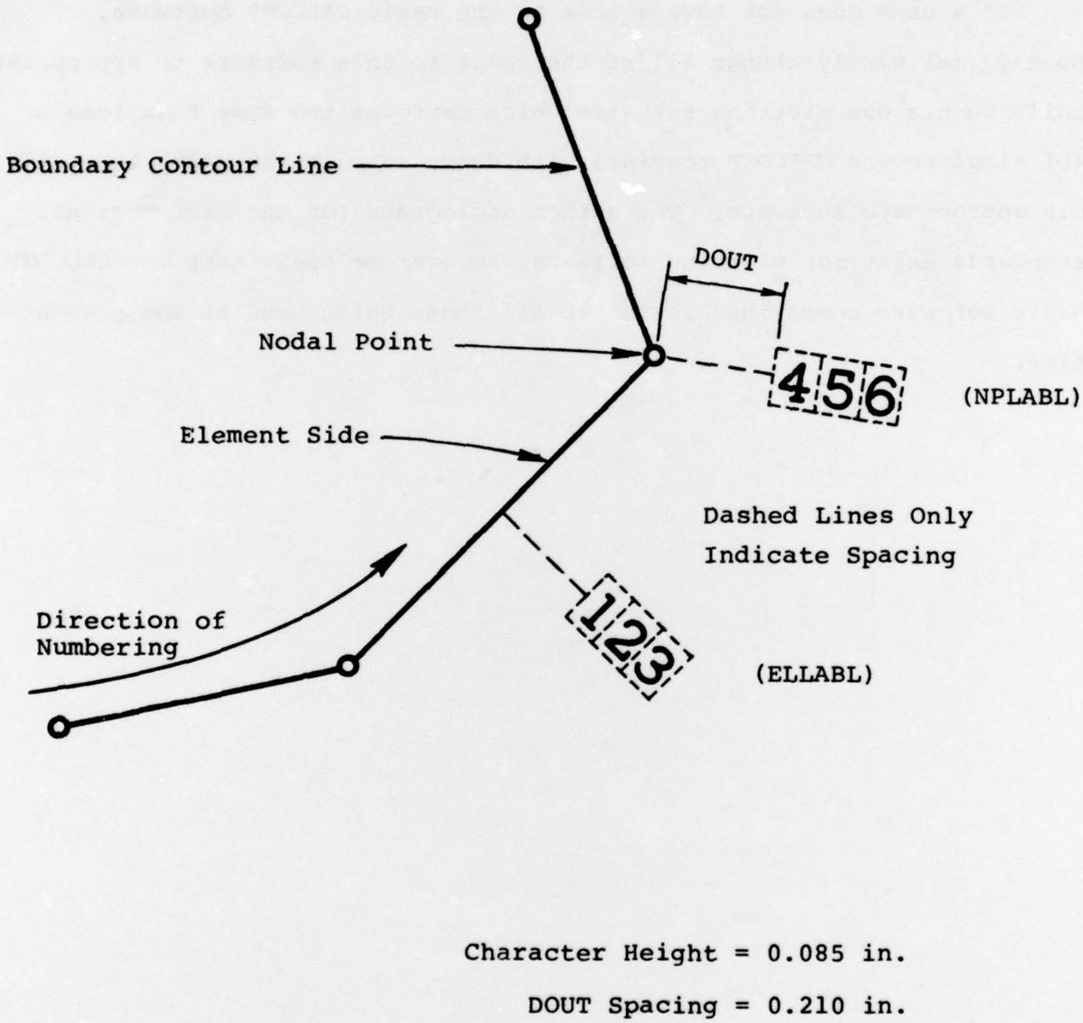


Figure 21. NPLABL and ELLABL Annotation

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